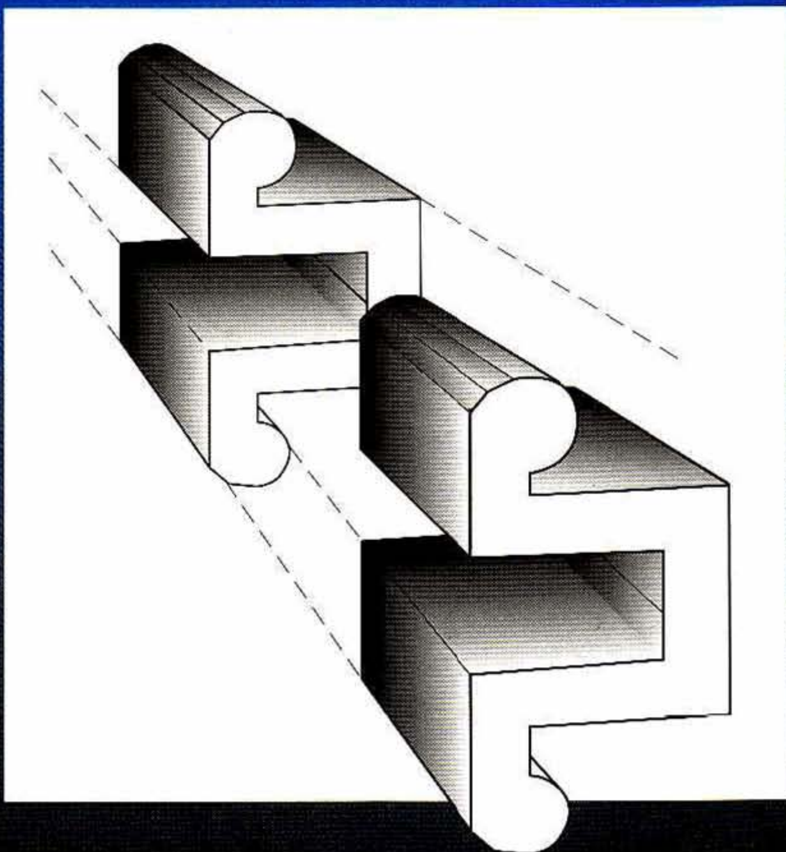
FIXED ORTHODONTIC APPLIANCES

PRINCIPLES AND PRACTICE



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Principles and Practice

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Contents

Authors' notes

Imperial measurements have been used for archwire thickness because the conversion of rectangular wire measurements into metric equivalents gives inconvenient numbers.

Force is measured in grams rather than Newtons as commercially available measuring gauges are calibrated in grams.

The diagrams were produced by the authors using Harvard Graphics 3 (Software Publishing Corporation).

The Leeds Dental Institute have assisted in the preparation of a number of the photographs.

Foreword

The popular handbook, *An Introduction to Fixed Appliances*, was first published more than twenty years ago. Since then, it has been translated into no fewer than six languages and has attracted a worldwide audience. This venerable publication has now been replaced by a new book, *Fixed Orthodontic Appliances*, freshly illustrated and totally rewritten by an augmented team of authors.

The aim of this new book is to explain both the mechanical and clinical principles of orthodontic treatment with fixed appliances. The concise text and clear diagrams make it essential reading for first-year specialty students, as well as for interested general practitioners and advanced students of dentistry.

Given the primacy of fixed appliances, both in orthodontic speciality education and in clinical practice, it is surprising that there are so few books devoted specifically to the 'nuts and bolts' of multibanded/bonded therapy. I am pleased that this obvious deficiency has been rectified.

In the spring, before the start of our master's program, I often am contacted by new residents eager to find out what they can read to give them a head start. Lacking a ready, appropriate assignment, I generally have taken refuge in the glib assertion that there is little for them to do but steel themselves mentally for the rigors of the program that awaits. This new book now provides both me and my students with a better answer. I am pleased and honored to have participated in its publication.

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Preface

The sophistication and capability of fixed orthodontic appliances has advanced dramatically in the last decade. Efficient, acceptable, economical and safe fixed appliances are now widely available. Together with these developments is an increasing awareness of the benefits of orthodontic treatment, and a continuing interest in the quality of result, both among dentists providing and patients seeking treatment. These factors have inevitably stimulated a great deal of interest in the use of fixed appliances.

There has also been a significant simplification of the processes associated with the use of fixed appliances. In particular, the advent of bracket bonding has made it no longer necessary to maintain an expensive inventory of bands. Preformed archwires and accessories reduce the time required for appliance adjustment. Modern materials offer much improved physical characteristics, and the availability of 'aesthetic' appliances has resulted in an increase in the number of patients requesting treatment.

Unfortunately, the readiness with which fixed appliances can now be provided carries with it the danger of their use in inexperienced hands. Fixed appliances are no longer difficult to fit, but beginners will find them difficult to learn to use in a safe and efficient manner. The mechanical principles are relatively straightforward, and much of this book is concerned with them. The principal objective, however, is to begin the process of cultivating an awareness of the manner in which fixed appliances work, and to relate mechanism to physiology. It is only by paying careful attention to the interrelation of forces that a safe and effective use of appliances can be assured.

The book is mainly concerned with mechanisms appropriate for moving teeth with fixed appliances. It gives general guidance on the positioning of teeth with the aim of achieving an excellent functional, aesthetic and stable result. Successful treatment also depends upon a meticulous attention to diagnosis and treatment planning, which is beyond the scope of the book.

We have placed emphasis on simplicity and clarity rather than on exploring the full complexity of issues. References, where appropriate, are provided at the end of chapters for further reading. The chapters are arranged in a manner which corresponds to the sequence of procedures which will be followed in the clinical situation. In recognition of the probable use of this book as a reference for specific orthodontic topics, a certain amount of repetition has been necessary in order that each chapter is self-contained, and can be read in isolation.

The authors' intention is to provide a basic understanding of fixed appliance mechanisms. Further clinical and practical instruction will be required before this knowledge can be safely put into practice.

1

The scope of fixed appliances

The purpose of this book is to provide the newcomer to orthodontics with a basic understanding of the use of fixed orthodontic appliances. Before this can be done it is important to give some consideration to the justification for, and the aims of, orthodontic treatment.

Justification for orthodontic treatment

There are two clear justifications for orthodontic treatment: aesthetics and function. Orthodontic treatment can not only improve dental alignment but, in certain cases, can also have a profound effect upon the facial appearance of the individual. An unattractive dental or facial appearance has been shown to have an adverse effect upon an individual's psychological development. It also can affect the individual's acceptance by his or her peers and even influence career prospects. There is, therefore, an increasing demand for orthodontic treatment.

There is some evidence that improved dental alignment can result in an improved standard of oral hygiene, but there is little support for the claim that orthodontic treatment will lead to an increased longevity of the dentition through a reduction in periodontal disease or caries. Certain features of malocclusion, such as an anterior open bite or Class III incisor relationship, are associated with a speech abnormality and correction of the malocclusion may be justified on these grounds. There is also evidence to show that individuals, especially boys, with prominent upper incisors are more prone to trauma of the upper anterior teeth than those with a normal overjet.

It would appear that adequate mastication is possible with most irregularities of the teeth, although the inability to chew certain foods may be a major reason for patients with an anterior open bite seeking treatment. Occasionally a traumatic relationship of the teeth may exist whereby the patient's dental health may suffer if orthodontic treatment is not undertaken, and here there is a clear justification for orthodontic treatment.

The relationship between malocclusion and the symptoms associated with the temporomandibular joint (TMJ) and its related musculature is less clear. While there is increasing evidence that orthodontic treatment may be beneficial rather than detrimental in this respect, the relationship is unclear and it is not considered advisable to attempt to correct a malocclusion with the sole aim of alleviating or preventing TMJ symptoms. However, if orthodontic treatment is undertaken, the operator should aim to produce an intercuspal position with as many teeth in contact as possible and an occlusion free of occlusal interferences in function.

It is a matter of fundamental importance for the operator to identify the potential benefits of treatment. Unless there is a clear benefit available to the patient, treatment should not be commenced. Orthodontic treatment is not without risk. Such problems as enamel decalcification, root resorption and traumatic facial injury with headgear are well documented and

must be balanced against the benefits to be gained from treatment. This becomes even more important when the guarantee of a stable end result cannot be given. The risk/benefit analysis of each individual case should be discussed fully with the patient and parents before embarking on treatment. The points to be covered are listed in Appendix 1.

Aims of orthodontic treatment

The goal of orthodontic treatment has been defined by Proffit (1993) as 'the creation of the best possible occlusal relationships, within the framework of acceptable facial aesthetics and stability of the end result'. Indeed, the prime aim of orthodontic treatment is to produce a dento-facial appearance that is aesthetically pleasing, with good function and with the teeth in a stable position. A conflict of interest arises when an improvement in the alignment can only be achieved by moving teeth into an unstable position. A 'risk/benefit analysis' must be made and a treatment plan formulated which meets the perceived requirements of both **patient** and **operator**. Orthodontic treatment should not be undertaken unless a significant and lasting improvement can be offered and, for this reason, many of the milder malocclusions are probably better left untreated. Various 'indices of treatment need' are available as a guide to the operator when deciding upon the justification of treatment.

The aims of orthodontic treatment may be summarized as follows:

- relief of crowding;
- correction of the rotational and apical displacement of teeth;
- correction of the interincisal relationship;
- establishment of a satisfactory buccal intercuspation;
- a pleasing facial appearance;
- a stable end result.

Stability

It must be stated at the outset that it is simply hopeless merely to move teeth into good alignment and expect them to remain there. The factors which determine the 'stable' position of the teeth are not certain, but a good starting point is to regard the teeth as being in a zone of muscular balance between the soft tissues, and movement away from this zone may increase the risk of an unstable result. The collagenous matrix of the periodontal ligament tends to act as a 'buffer' and moderates small degrees of force imbalance within this zone of stability. Further movement from the zone or a reduction in the health of the periodontal support may 'tip the balance' and result in instability of tooth position. Certain environmental factors such as aberrant soft tissue behaviour, the presence of a digit-sucking habit, or loss of periodontal bone support may have an influence on the position of stability.

The factors determining the positions of stability are impossible to identify with precision and would appear to change throughout the patient's life. We consider it is wrong to believe, and indeed to advise the patient, that orthodontic treatment will move the teeth into a new position into which they will stay forever more. **This is simply not the case**. Teeth have been shown to move throughout life, whether orthodontic treatment has been undertaken or not. The general tendency with age is for a reduction in both the arch-length and arch-width dimensions and for an increase in crowding. An awareness by patients of this fact may help an acceptance of some of the smaller tooth movements that may occur following the completion of a course of orthodontic treatment.

Certain tooth movements are associated with a greater risk of relapse. A description of these and the measures suggested to reduce their magnitude are covered in Chapter 15.

Labial segments

A major consideration in the stability of orthodontic treatment is the labiolingual position of the lower incisor crowns. There are certain situations in which alteration of the lower incisor position is desirable and a stable result may be achieved, but considerable experience is required to recognize and treat these cases. The authors advise that during treatment the pre-existing labiolingual position of the lower incisor crowns is maintained, and that alignment of the lower labial segment is achieved by the adequate relief of crowding. Movement of the teeth in the labial segment out of the zone of soft tissue balance is unlikely to be stable and, following removal of

appliances, crowding is likely to recur in the lower arch as the incisors return to their initial axial inclination. This may result in a relapse of a previously reduced overjet and overbite, or secondary upper arch crowding may occur as both upper and lower labial segments move palatally, so reducing arch length. Alignment of the lower incisors must therefore be achieved by the appropriate extractions to relieve crowding and the distal movement of the lower canines.

Interincisal angulation

The interincisal angulation in a Class I incisor relationship is normally between 130° and 135°. It may not always be possible, or indeed desirable, to achieve this angulation, yet the larger the interincisal angulation, the greater is the chance of an increased overbite becoming established. In extreme cases, where overjet reduction has been carried out by an inappropriate degree of retroclination of the upper incisors, a potentially traumatic overbite can develop (Figure 1.1).

Buccal intercuspation

It is also desirable at the end of treatment to have a good buccal intercuspation. If the cusps of the premolars and molars are not satisfactorily interdigitating at the completion of treatment, then occlusal forces may predispose to movement of the teeth in either arch. This can lead to the relapse of an increased overjet or the development of crowding. Treatment plans which involve symmetrical extractions in both arches will normally necessitate a Class I buccal segment relationship at the end of treatment. In some Class II division 1 malocclusions with uncrowded lower arches, it is possible to limit the extractions to upper premolars only, in which case the molar relationship will be Class II at the end of treatment. Provided there is a good intercuspation, a Class II molar relationship is acceptable as a treatment goal.

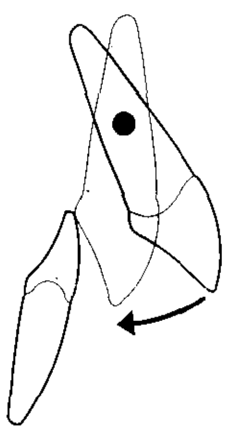

Figure 1.1 An increased overjet reduced by excessive incisor tipping may result in a traumatic overbite

Soft tissues

The position of the teeth is related to the morphology and action of the soft tissues. Certain abnormalities of tongue or lip behaviour are liable to cause relapse of a treated malocclusion. Many Class II division 1 cases have an adaptive tongue thrust, which is secondary to the increased overjet. Once the overjet has been corrected the tongue thrust ceases. There are a few individuals who exhibit a so-called 'endogenous' or 'primary tongue thrust' which will persist after treatment. Such tongue thrusts are frequently associated with an anterior open bite extending into the buccal segments and an anterior sigmatism. The practitioner should be able to recognize these and be aware of the doubtful prognosis for treatment.

A persistent digit-sucking habit will also affect tooth position, often producing an anterior open bite, an increased overjet and a posterior crossbite.

The aim of treatment, particularly in Class II division 1 malocclusion, is to alter the position of the upper incisors relative to the lower lip and to move them from a position of stability **outside** the lower lip into a new position of stability **inside** the lower lip. This is achieved when the lower lip rests in front of the upper incisors and covers at least a third of their labial surface. It is also important to ensure that the overjet is adequately reduced, so that the lower lip cannot become 'trapped' behind the upper incisors and cause relapse. A treatment plan that aims for partial reduction of the overjet is in danger of producing an unstable result. A small number of patients exhibit a particularly tight lower lip, the excessive action of which is often seen during talking or smiling. This has become known as an 'expressive' or 'strap-like' lower lip. The treatment of patients with this type of lip pattern associated with a Class II division I occlusion is quite likely to relapse if overjet reduction is attempted.

Tooth movement with fixed appliances

Having briefly discussed the philosophy of tooth movement, it is now appropriate to discuss how these aims of treatment can be achieved. A comparison between the various orthodontic tooth movements that are possible, and the method of applying a force in order to achieve these movements, will illustrate the potential of fixed appliances. The movements that are to be considered are tipping, uprighting and torqueing, bodily movement and rotation.

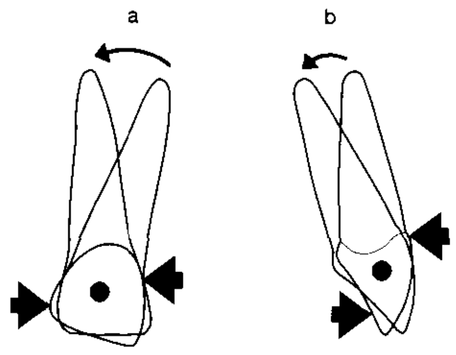

Figure 1.3 (a) Uprighting; (b) torqueing

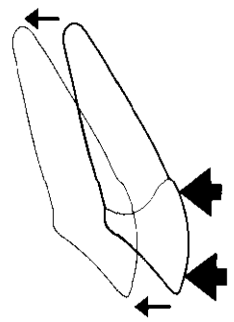

Figure 1.4 Bodily tooth movement

Tipping

Tipping is the easiest form of tooth movement to achieve and is produced by the application of a single force to the crown of tooth. The tooth moves under the influence of the force in the direction of least resistance. It is important to note that the tooth does not tip about the apex but rather about a fulcrum which is established within the root of the tooth. The crown moves in the direction of the applied force and the root apex moves in the opposite direction (Figure 1.2).

Many malocclusions cannot be satisfactorily treated by means of simply tipping teeth in the manner described above. Fixed appliances are capable of producing tipping movements, but by applying a **force couple** to the crown of the tooth it is also possible to achieve control of the apical position.

Uprighting and torqueing

If a force is applied to a tooth, it will move by **tipping**, unless it is prevented from doing so. When either uprighting or torqueing forces are applied to a tooth, tipping is prevented and some degree of controlled movement of the apex occurs. We define uprighting as the intentional mesial or distal movement of apices and torqueing as the labial or lingual movement of the root apices. Both uprighting and torqueing require the application of a force couple to the crown of the tooth in such a way that the fulcrum lies within the crown (Figure 1.3). It is here that the management of tooth movement becomes more difficult because these movements aim to control the **apex** of the tooth by applying a force to the **crown** of the tooth, some distance away.

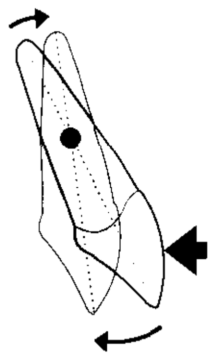

Figure 1.2 Tooth tipping by applying a single force to the crown of a tooth

Bodily movement

Bodily movement of the teeth implies an equal movement of the crown and apex in the same direction. It is not possible to move a tooth bodily by the application of a force to the crown of the tooth unless the tooth is prevented from tipping. Although difficult, this type of tooth movement can be achieved using a fixed appliance designed in such a way that a force couple is applied to the crown of the tooth so that the apex moves in the same direction as the crown (Figure 1.4). Pure bodily movement is relatively

easy to visualize but in reality rarely occurs. In clinical practice there is almost always a degree of tooth tipping and usually a separate stage of apical positioning is required.

Rotation

Rotation of teeth around their long axis again requires the application of a force couple to the crown. There is considerable mechanical difficulty in applying an efficient force couple with a removable appliance. However, with a fixed attachment on the tooth to be rotated, precise rotational control can be obtained, especially if a wide bracket is used (Figure 1.5). A further advantage of using fixed appliances for rotational correction is that any abnormality of apical position, so frequently associated with rotated teeth, can be corrected simultaneously.

Specific indications for the use of fixed appliances

Grossly misplaced teeth

When the crown or apex of a tooth is markedly displaced from the arch, particularly when movement in an **occlusal** direction is required, fixed appliances are essential. In such instances the crown of the tooth will be inaccessible to a removable appliance spring. If an attachment is placed on the displaced tooth, a site is thereby provided for the application of an appropriate force (Plate 1).

Lower arch treatment

Removable appliances are rarely used to move teeth in the lower arch. They tend to be bulky, have poor retention and the springs are often inefficient. Fixed appliances offer a much more efficient means of moving lower teeth (Plate 2).

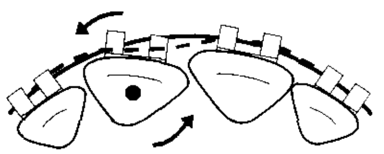

Figure 1.5 A force couple is created when the archwire is engaged in the bracket of a rotated tooth

Space closure

When a fixed appliance is used, apical as well as coronal correction can be achieved. Such space closure is advisable for the treatment of malocclusions where extractions provide more space than is required for the relief of crowding, or where teeth are congenitally absent. Space closure is best undertaken in this manner so that the roots of the teeth are parallel at the end of treatment. This is an important goal of orthodontic treatment that will be discussed later in more detail (Chapter 15).

Incisor relationship

In a Class II division 1 malocclusion the reduction of overjet is often required. Tipping the incisors palatally may often be acceptable but where there is an antero-posterior skeletal discrepancy, palatal movement of the upper incisor apices is usually required.

Fixed appliances, by virtue of the fact that they have some control over apical movement, can be used to reduce an overjet without excessive tipping, thereby producing a satisfactory incisor relationship (Plate 3). Many Class II division 2 incisor relationships and bimaxillary incisor proclination can **only** be corrected using fixed appliances, because of the necessity of altering the apical position of both upper and lower incisors in order to achieve a stable change in the interincisal angle. Such cases are not suitable for those with limited experience in the use of fixed appliances.

Multiple tooth movement

Fixed appliances allow for control of the position of several teeth or groups of teeth in both arches. Simultaneous tipping, rotation and apical movements are possible and intramaxillary, intermaxillary and extra-oral forces can be effectively applied. However, the ability of fixed appliances to perform these complex and concurrent series of tooth movements makes it essential that the operator monitors the appliance and its effects with great care.

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2

Anchorage

The term 'anchorage' has given rise to a great deal of confusion, and has often hindered an understanding of orthodontic appliances. The basic concepts however are not difficult to understand, and indeed they must be understood if fixed appliances are to be used in a predictable manner.

Orthodontic treatment is concerned with the application of forces to the crowns of teeth. These forces are generated by active components, for example by springs, archwires and elastics. The active component produces a force in one direction, and an equal and opposite force in the opposite direction. This is expressed in Newton's Third Law of Motion – 'Every action has an equal and opposite reaction.'

The force which produces the required tooth movement is inevitably associated with an opposing force of equal magnitude. Active orthodontic appliances, whether removable or fixed, will apply a force which needs to be resisted. In orthodontics the structures resisting the opposing force are referred to as **anchorage**. The anchorage may be derived from intra-oral and extra-oral sources. The issue of relevance in orthodontic treatment is the effect of these opposing forces in terms of tooth movement.

In the simplest situation the objective will be to achieve maximum response in the teeth to be moved and no movement of the structures providing anchorage.

In practice however, and particularly when anchorage is provided intra-orally, it must be anticipated that the force which is being resisted will produce movement of the anchorage. This is referred to as **anchorage loss**.

The concept of intra-oral anchorage being immovable is misleading. A more appropriate concept is that of **anchorage management**, which involves restricting movement of one group of teeth while facilitating movement of other teeth.

Anchorage considerations apply to tooth movements in any plane of space. If the appliance is to achieve the necessary tooth movements then the operator must anticipate and control the effects of opposing forces throughout treatment. Anchorage management is the exercise of this control. Without effective anchorage management it will not be possible to achieve an ideal result.

Anchorage value

In every situation in which force is being applied it is possible to identify:

- the teeth to be moved;
- the active component applying the force;
- the anchorage resisting the opposing force.

The issue of central importance is that forces of equal magnitude are being applied both to the teeth to be moved and to the anchorage, and that these forces are in opposite directions.

The essential characteristic of effective anchorage is its resistance to movement.

In the case of extra-oral anchorage there is at least theoretically a limitless supply of 'immovable' anchorage. The clinical use of extra-oral anchorage is described in Chapter 9.

With intra-oral anchorage, however, there is, in the vast majority of cases, a finite limit to the

amount available. An ankylosed tooth, or a dental implant, will offer 'immovable' anchorage, but when healthy teeth are being used to resist the opposing force anchorage loss must be anticipated. The extent to which intra-oral anchorage is able to resist movement – that is, the value of the anchorage – is directly related to the effects of the force on the structures providing anchorage.

The basic determinants of anchorage value are:

1. the force magnitude which has to be resisted;
2. the pressure distribution in the periodontal ligament;
3. root morphology;
4. the space available;
5. neighbouring structures.

Force magnitude and anchorage value

Light forces are sufficient to exceed the threshold for tooth movement. There is, however, an upper limit, which if exceeded results in delayed tooth movement, associated with the risk of damage to both the tooth and its supporting tissues. The 'physiological force' concept identifies an optimal force magnitude which results in maximum tooth movement together with the least risk of damage.

Figure 2.1 illustrates a theoretical force/movement graph. Ascending the slope towards the optimal force indicates progressively increasing applied force resulting in progressively increasing rate of movement.

Beyond the optimal force there is no longer a proportional relationship between force applied and rate of tooth movement. Increase in applied force does not result in an increased rate of tooth movement and the graph shows a plateau which clinically would be demonstrated by reduced tooth movement.

Progressively increasing the force beyond the optimal value risks producing damage to the tooth and its supporting tissues.

Proffit suggests the following 'optimal forces' for different tooth movements:

Tipping:	50–75 gm force tooth
Bodily movement:	100–150 gm force tooth
Uprighting:	75–125 gm force tooth
Rotation:	50–75 gm force tooth
Extrusion:	50–75 gm force tooth
Intrusion:	15–25 gm force tooth

When considering the possible effects of a given force, the important factor is not the absolute magnitude of the force, but the pressure (the force per unit area) generated in the periodontal ligament. The surface area of the root supported by the alveolar bone is therefore an important determinant of the effect of the applied force. A given force might be sufficient to initiate the cellular reactions leading to movement in a tooth with a small root area, but insufficient for movement of a tooth with a large root area. Average figures for root surface areas are given in Figure 2.2.

The force which might be optimal for producing tooth movement of a lower incisor would be less than optimal for moving a molar. The **rate of movement** of the lower incisor will be at a maximum whereas the same force applied to the molar will either be insufficient to produce any movement at all, or more likely will produce movement at a very slow rate.

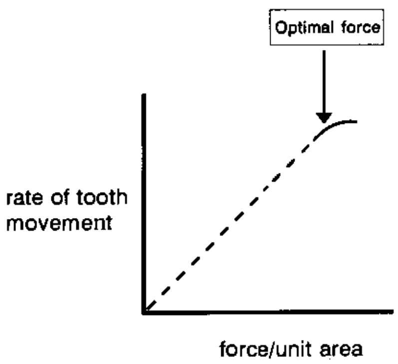

Figure 2.1 The theoretical relationship between force applied and rate of tooth movement

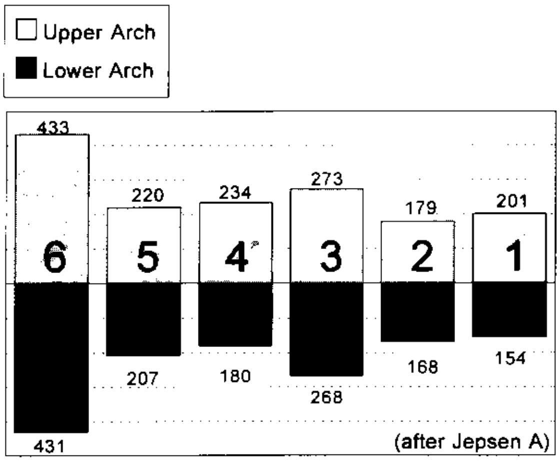

Figure 2.2 Root surface areas (in sq mm)

In terms of anchorage management, if it is necessary to make a tooth or group of teeth resistant to movement, then the force per unit area in the periodontal ligament must be kept low. If on the other hand it is necessary to facilitate the movement of a tooth or a group of teeth, then the force per unit area should be in the 'optimal' range.

This concept embodies the first principle of orthodontic anchorage. A tooth with a large supported root surface area has a greater anchorage value than a tooth with a small root surface area. Similarly, the anchorage value of a group of teeth with a large total root area is greater than the anchorage value of a group of teeth with a smaller root surface area.

In practice, it is impossible to determine the precise supported root area of a tooth or teeth providing anchorage, but the relatively large variation in root areas given in Figure 2.2 provides a useful guide. It is important to emphasize that it is the area of root supported in the alveolar bone which is of importance. Teeth affected by recession of the alveolar bone, such as may be seen in adults or patients with periodontal disease, will offer less anchorage value. Considering the irregularly conical form of roots, loss of alveolar bone height has a disproportionately large effect on the reduction of supported root area. Teeth with shortened roots will also have a reduced anchorage value.

When forces in excess of the optimal force are applied the rate of tooth movement reduces (Figure 2.1). These heavy forces produce undermining rather than direct alveolar bone resorption and tooth movement is slow and irregular. The possibility presents itself of using heavy forces in this way to increase anchorage value. Unfortunately, such an approach is unwise because heavy forces carry the risk of damaging the teeth and their surrounding structures, and giving rise to avoidable pain.

Pressure distribution and anchorage value

Anchorage value is influenced to a considerable extent by the distribution of pressure in the periodontal ligament. The pressure distribution is in turn determined by the complexity of the applied force – specifically, whether it is a single force applied to the crown of a tooth or whether it is a force couple. When a single force of appropriate magnitude is applied at right angles to the long axis of a tooth, and no other restraint

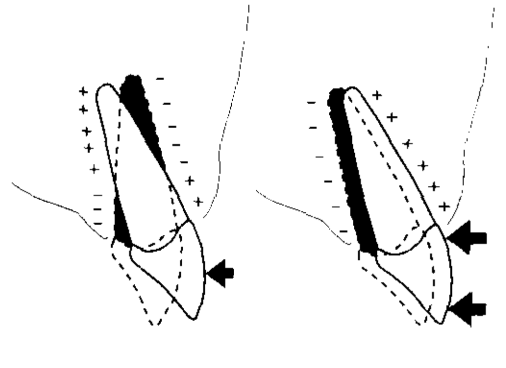

Figure 2.3 (a) A single force of low magnitude will produce tipping if no other restraint is present. (b) Bodily movement requires the application of a force couple. A greater force is necessary than for tipping movements. Areas marked (+) where bone is laid down, where bone is resorbed (−)

to tooth movement is present, the tooth will tip in the direction of the applied force (Figure 2.3(a)). When a tooth tips in this way, the angular change occurs relatively quickly, and the force required is relatively low in magnitude.

In Figure 2.3(b) the same tooth is prevented from tipping, and can only move bodily. In order to achieve this bodily movement the single force which would otherwise produce tipping must be supplemented by a second force, so that a **force couple** is active.

Two important issues should be recognised:

1. Bodily movement requires the application of a force couple, and the total force required will be greater than that required to produce tipping.
2. The movement of the crown of the tooth will occur more slowly when the tooth is moving bodily.

The second anchorage principle is that a tooth which is free to tip has less anchorage value than a tooth which is restricted in tipping by the application of a force couple.

As palatal and lingual arches restrict tipping of teeth to which they are attached they are able to increase anchorage value significantly (Figure 2.4). They should be constructed from relatively inflexible wire (at least 0.9 mm diameter) and soldered to bands rather than being removable, because their ability to supplement anchorage depends upon rigidity. Arches of this design distribute the force which needs to be resisted – and they increase anchorage value by imposing

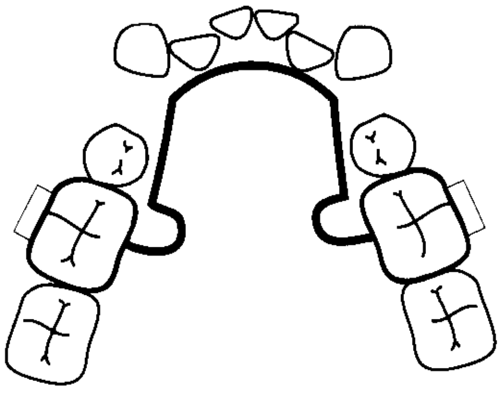

Figure 2.4 Lower lingual arch restricting the movement of the molar teeth

restriction on the movement of the anchorage teeth. Tipping, rotation and changes in arch width are impeded.

The effect of forces in different directions is not always immediately apparent in terms of the resulting pressure distribution in the periodontal ligament. Extrusion, rotation and intrusion seem to be special cases in terms of the effect of pressure distribution. It is, in practice, difficult to achieve pure extrusion or rotation without introducing tipping, and it is probably this factor which influences the 'optimal force' and hence the resistance to movement.

In the case of intrusion, pressure distribution will be at a maximum in the apical region – that is, over a small area. Relatively low forces are appropriate for producing intrusion, although the production of a force directly along the long axis of a tooth may be difficult to achieve in practice.

Root morphology and anchorage value

The root morphology of teeth influences the force distribution in the periodontal ligament, and the relative flatness of certain tooth roots influences their anchorage value. Lower incisor roots, for instance, are narrower mesiodistally than buccolingually. They therefore offer less resistance to proclination or retroclination than to movement along the line of the arch. Lower incisors have relatively small root surface areas in any case, but they offer particularly low resistance (and anchorage value) to labiolingual movement. Molar teeth, however, with a large root surface area, will offer a greater resistance to movement.

Space availability and anchorage value

Accepting that teeth providing intra-oral anchorage must be expected to move under the influence of the forces applied to them, the value of their anchorage will depend upon how far they can be permitted to move without encroaching upon the space required for the alignment of other teeth. In other words, teeth which can be allowed to move a considerable distance under the influence of the reciprocal force offer greater anchorage value than those which can only be allowed to move slightly. There is therefore an association between anchorage value and the amount of space available. In some cases it is necessary to extract teeth in order to provide additional anchorage. Anchorage management involves identifying the type of tooth movement, the distance teeth are to be moved and the forces required. Insufficient anchorage value may result in further crowding or a compromised planned tooth movement. It should be remembered that even without reciprocal forces being applied there is a tendency for mesial drift and forward movement of teeth in the buccal segments when crowding is present.

Neighbouring structures and anchorage value

The quality of the alveolar bone surrounding the root has an influence over the tooth's anchorage value. Teeth move more rapidly, and the movement requires less force, when the supporting bone is cancellous – when in other words the root is moving within the trough of cancellous bone. If the root comes into contact with denser cortical bone, then the rate of movement is reduced. When the rate of movement is reduced because of contact with dense cortical bone the danger of applying excessive force is that of initiating root resorption. In some situations, the process of intruding lower incisors will move the roots into contact with the lingual cortical plate. The lower incisors will then offer greater resistance to intrusion.

Neighbouring teeth, both erupted and unerupted, may inadvertently increase the anchorage value, depending upon the direction of the force being resisted by the anchorage. Deficiency of alveolar bone (for instance, shortly following tooth extraction) may reduce the anchorage value of neighbouring teeth. On the other hand, excessively traumatic extraction of teeth may at a later stage result in 'necking' of the alveolus,

and areas of dense bone at the extraction site, making movement of neighbouring teeth into those areas difficult or impossible to achieve.

Theoretically at least, the forces applied by surrounding soft tissues both in respect of their morphology and their activity, may influence anchorage value. These soft tissue forces are usually small compared with those associated with the appliance, but they may be important in some situations. A lower fixed appliance incorporating a lip bumper for instance, utilizes the anchorage afforded by the lower lip to prevent forward movement of the lower molars (Figure 2.5).

A palatal arch may incorporate an acrylic 'button' which is in contact with the anterior slope of the palate. This button will add to the anchorage value by increasing the resistance of the palatal arch to movement in an anterior direction (Figure 2.6).

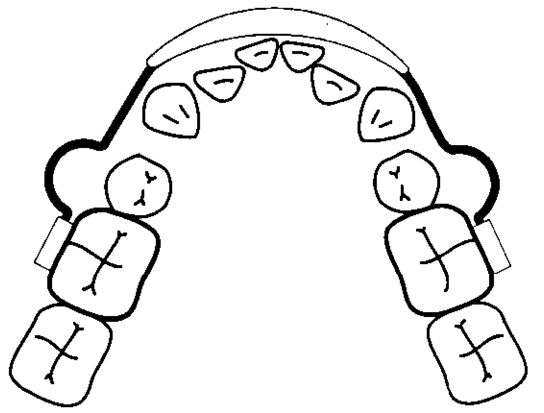

Figure 2.5 Lower lip bumper to restrict forward movement of lower molars

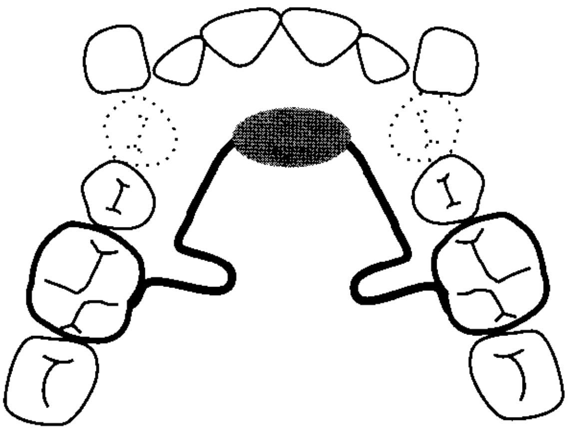

Figure 2.6 Palatal arch with acrylic button to increase resistance to forward movement

Anchorage management

Anchorage management involves the provision of sufficient anchorage value to enable the required tooth movement to be achieved. In different cases, and at different stages in a particular treatment, anchorage requirements will vary. The resistance of one group of teeth must be balanced against another so that at the end of treatment the best final tooth position has been realized.

The usual problem when treating crowded cases with a considerable amount of initial tooth displacement is that of dealing with a situation in which anchorage needs to be carefully conserved. On the other hand, patients with considerable amounts of spacing present a different problem because space closure also places demands upon anchorage. Most malocclusions will lie somewhere between these extremes. If the orthodontist is to achieve the best final tooth positioning, anchorage conservation will be required at some stages and intentional anchorage loss at others.

The balancing process which is central to intra-oral anchorage management depends upon controlling the value of the anchorage.

Controlling anchorage value

Increasing the anchorage value involves making the teeth providing anchorage more resistant to the force which is being applied to them. There are a number of possibilities:

1. Incorporate as many teeth as possible in the anchorage unit.

   Additional teeth increase the root area over which the applied force is distributed. The anchorage unit as a whole moves 'down' the force/movement slope (Figure 2.7.). In practical terms, the incorporation of second permanent molars (in addition to first molars) into the anchorage unit is a useful way of increasing molar anchorage value.

   Apart from incorporating as many teeth as possible into the anchorage unit, it is wise to reduce the number of teeth to be moved in one procedure. The important issue is the comparison between the root areas of the

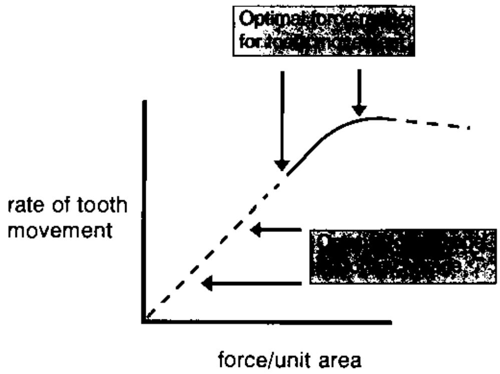

Figure 2.7 By increasing the root surface area of the anchorage unit the force per unit area moves down the force/movement slope

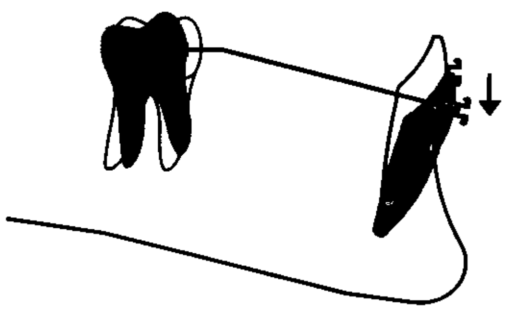

Figure 2.8 Effect of anchorage bend

anchorage unit and that of the teeth to be moved. If the root areas are similar, then both groups of teeth will lie on the same point on the force/movement graph, and providing no other restraint to tooth movement is applied, then both groups will move at the same rate towards each other. If it is necessary to restrict movement of the anchorage unit, its position on the slope of the graph must be lowered by increasing the root area.

2. Use anchorage bends. An anchorage bend is placed in the horizontal plane of the archwire 2–3 mm in front of the molar tube (Figure 2.8). The effects of this bend are as follows:
   (a) A distal tipping force couple is applied to the molar. This force couple will restrict forward tipping of the molar, so increasing its anchorage value against mesially directed forces.
   The degree of anchorage bend used must not be too great, or significant distal tipping of the molar will be produced. As a general guide, in situations where the molar is upright, the bend should be 30°.
   (b) An extrusive force is applied to the molar (the reciprocal to the intrusive force applied to the incisors). This tendency for molar extrusion is opposed by the forces of occlusion, but it may produce unwanted increase in the maxillary mandibular planes angle.
   (c) An intrusive force is applied to the incisors, leading to a reduction in overbite. If this intrusive force is not acting through the centre of resistance of the incisors, their angulation will change.

   In some situations incisor intrusion is undesirable. It will then be necessary to increase molar anchorage by means other than by the use of anchorage bends, or to change the balance of forces applied to the incisors to oppose the intrusive effect of the anchorage bends.
3. Control of pressure distribution in the periodontal ligament. If the teeth providing anchorage are prevented from tipping, their anchorage value is increased. Consideration must be given to the relative resistance of the anchorage unit compared to the resistance of the teeth to be moved. If the teeth to be moved are free to tip, but a force couple demanding bodily movement is applied to the teeth in the anchorage unit, then the balance is in favour of maximum movement of the teeth free to tip and minimum movement of the anchorage unit. Under these circumstances, consideration of the relative root areas remains a matter of importance, but is less important than if both groups of teeth are subject to the same pressure distribution in the periodontal ligament.
4. Reduce the force applied to the optimal for producing the required tooth movement.
   Forces in excess of the optimal place unnecessary strain on the anchorage, and the position of the anchorage unit on the slope of the force/movement graph rises. In clinical practice the reciprocal increase in force delivered to the anchorage unit makes these teeth more likely to move. It is safe practice, and is advisable in terms of anchorage conservation, always to use the **least** force necessary to achieve the required tooth movement.
5. Reinforce the intra-oral anchorage with extra-oral anchorage.
6. Use a palatal or lingual arch to restrict tipping, rotation and change in arch width.

7. Use intermaxillary forces.
   Intermaxillary forces are transmitted from one dental arch to the opposing arch. The forces are usually transmitted with the application of latex elastics. In this way the mandibular arch could provide anchorage for tooth movement in the maxilla, or vice-versa. The anchorage balance will depend upon the relative anchorage values in maxillary and mandibular arches.
8. Use a lip bumper in the lower arch to gain anchorage from the musculature of the lower lip.
9. Employ anchorage preparation. In some edgewise techniques the teeth planned to provide anchorage were first carefully positioned so that they could offer maximum resistance. This process would apply particularly to the molar teeth. In the anchorage preparation stage the molars are tipped distally, and in the lower arch the molar roots are moved buccally into contact with the cortical plate. When the anchorage teeth are in place their position is maintained using rigid rectangular archwires. In this situation the distally inclined molars will offer maximum anchorage against mesially directed reciprocal forces – a situation described as 'tent pegging'. In addition, the contact with the cortical bone will further add to the anchorage value.
   The need for such anchorage preparation has been reduced for a number of reasons, mainly as a result of the widespread use of light forces resulting in less strain being placed upon intra-oral anchorage. It is mentioned here to illustrate the perfectly valid principles underlying its use.

In some circumstances it will be necessary to prevent any movement of the anchorage unit. In that case the use of extra-oral anchorage will need to be considered, together with the other possibilities described above as appropriate.

In other situations it may well be possible to achieve the required result employing only intra-oral anchorage. The principle of balancing the resistance of one group of teeth against another is central to the process of anchorage management. It has been referred to as the use of **differential forces** (as described by P.R. Begg). The concept is that of using light, carefully controlled force magnitudes to produce differential responses in different groups of teeth.

Anchorage, archwires and brackets

The archwire channel of edgewise brackets is relatively wide, so that compared with Begg brackets the freedom of teeth to tip along the archwire is restricted. The relationship between archwire and bracket will influence tooth movement. The thicker the archwire the greater is the restriction to tipping. Small-diameter round archwires in rectangular bracket slots leave space between the bracket channel and the archwire. This space will allow tipping of the tooth around and along the archwire in both a mesiodistal and buccolingual direction. The more accurate the fit of the archwire to the bracket slot the more resistance there will be to tipping movements. When rectangular archwire is in use further restraint is placed on the tooth's freedom to move in relation to the archwire. Restriction of the freedom to tip implies the need to apply greater forces, and therefore greater strain being placed on the anchorage unit. In general, edgewise appliances place greater demands upon anchorage than Begg appliances, and more frequently demand the use of extra-oral anchorage. It appears that bodily tooth movement requires more anchorage than the quite separate technique of tipping followed by uprighting as used in the Begg technique.

Anchorage planning

The aim of orthodontic treatment is to move teeth into prescribed positions. Sufficient space must be available into which to move the teeth, and the process involves the application of forces which have 'equal and opposite reactions'.

The reaction to the forces used to achieve intentional tooth movement must be resisted by the anchorage. The anchorage may be derived from intra-oral or extra-oral sources or a combination of both.

If the total value of the anchorage is insufficient then it will be impossible to achieve the required tooth positioning at the end of treatment. The operator must have an understanding of anchorage balance before commencing treatment. This will in many cases influence the decision over the need for and choice of extractions. The nearer the site of crowding that space is made available, the less anchorage will be required to achieve satisfactory tooth movement.

Extra-oral anchorage has the advantage of being potentially infinite in amount providing there is good patient co-operation. However, there is the disadvantage that it is generally unpopular with patients on the grounds of appearance and convenience.

Managing anchorage on a purely intra-oral basis has the advantage from the patient's point of view, but intra-oral anchorage is of finite amount. In practice it is impossible to assess the value of intra-oral anchorage with accuracy, and a further problem is that the mechanical complexity of the appliance usually defies precise definition of force values. Accepting these considerable areas of uncertainty, it is wise to consider the following guidelines in planning anchorage requirements:

1. Anticipate the anchorage requirements as a specific stage of treatment planning before appliances are fitted. The requirements will depend upon an assessment of space availability and required tooth movements. Tooth movements requiring a considerable amount of bodily tooth movement will place maximum demands upon the anchorage. It is for this reason that anchorage demands are greater in fixed than removable appliance treatment.
2. The final treatment plan should in general only be decided when the anticipated anchorage has been identified. Sometimes it may be impossible to decide upon a detailed treatment plan – for instance in a case in which it is not clear as to whether or not extraction of teeth is required. In such a situation it may be best to commence treatment on a non-extraction basis, bearing in mind the need to extract teeth at a later stage should anchorage considerations and the achievement of the best result demand it.
3. For the newcomer to fixed appliance orthodontics it is wise to overestimate the anchorage requirements. The ability to use extra-oral anchorage when indicated is a necessity.

   When extra-oral anchorage is required, it is usually best to use it from the commencement of treatment rather than to fit it at a later stage when there has been anchorage loss. If extra-oral anchorage is to be used at the beginning of treatment it is safe practice to assess the patient's compliance before continuing with a treatment plan which is dependent upon such anchorage.
4. The inevitable uncertainties of measuring anchorage value indicate the need for a continuing process of re-assessment at each visit. The operator must be aware of the tooth movements which are occurring, and refer to the pre-treatment records at each visit.

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3

Brackets

A fixed appliance has three basic components:

1. brackets;
2. archwire;
3. accessories.

The interaction of these three components determines the manner in which the appliance functions. The mechanical factors which determine the choice of fixed appliance components are related to the tooth movement required. A clear understanding of the aims of tooth movement in the different stages of treatment is essential if efficient and safe use is to be made of the appliance.

This chapter is concerned with brackets. The type of bracket to be used is a fundamental choice which must be made at the commencement of treatment – it will have a major influence on the mechanics of the appliance.

Brackets provide points of attachment on the crowns of the teeth so that the archwire and accessories can influence tooth position. They need to be rigidly attached to the teeth, either by direct bonding, or by using stainless steel bands to which they are spot welded.

Many different designs of bracket are available. For the purpose of understanding the principles of the manner in which fixed appliances function, it is useful to subdivide them as follows:

- brackets in which the archwire channel is wide mesiodistally – for example, edgewise brackets;
- brackets in which the archwire channel is narrow mesiodistally – for example, Begg brackets.

Edgewise brackets

Edgewise brackets have an archwire channel which is rectangular in cross-section, with the largest dimension horizontal. The term 'edgewise' refers to the ability of the bracket to accept a rectangular cross-section archwire with its largest dimension horizontal. Edgewise brackets can also be used with round cross-section archwires.

A number of different edgewise bracket designs are in use. Their principal characteristics are as follows:

1. *The occluso-gingival dimension of the archwire channel*
   Commonly used sizes are 0.018 in and 0.022 in (the labio-lingual dimension is usually 0.028 in) (Figure 3.1).

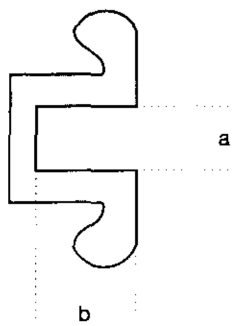

Figure 3.1 Lateral view of standard edgewise bracket: (a) occluso-gingival dimension (0.018 or 0.022 in); (b) labio-lingual dimension (usually 0.028 in)

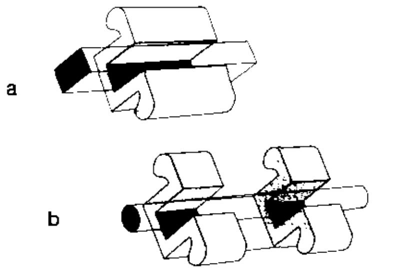

Figure 3.2 (a) Solid standard edgewise bracket with rectangular archwire; (b) Siamese standard edgewise bracket with round archwire

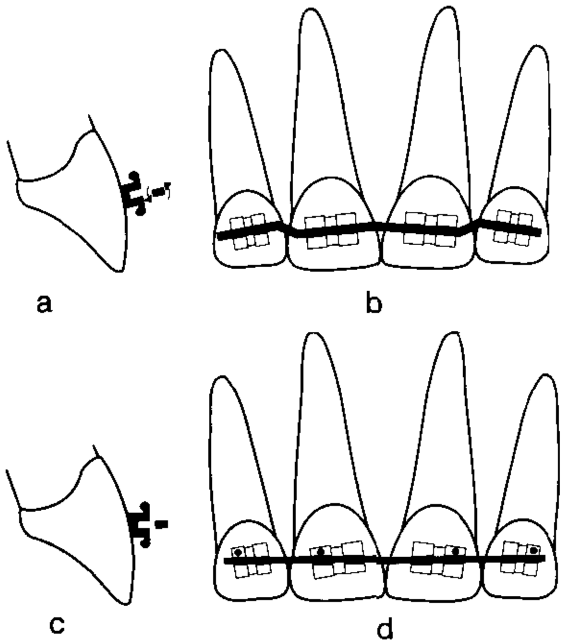

Figure 3.3 (a) and (b) Standard edgewise brackets, torque (a) and tip (b) must be bent into the archwire; (c) and (d) preadjusted edgewise brackets, torque (c) and tip (d) are built into the brackets

2. *The bracket may be solid as in Figure 3.2(a), or Siamese as in Figure 3.2(b)*
   Siamese brackets have two separate archwire channels.
3. *The mesiodistal width of the channel*
   The widest effective width is seen with Siamese brackets.
4. *The orientation of the channel and its distance from the bracket base*
   Standard edgewise brackets have the channel set in line with, and at a standard distance from, the bracket base (Figure 3.3(a)). With preadjusted edgewise brackets, the archwire channel orientation (Figure 3.3(c) and (d)), and its distance from the base (in/out), is determined individually according to the tooth to which it is to be attached (Figure 3.4).

Molar teeth are fitted with horizontal edgewise rectangular buccal tubes, usually with additional round horizontal tubes on the upper first molar bands for extra-oral traction if required (Figure 3.5). Second permanent molars may be fitted with similar attachments in order to achieve control over the position of these teeth, and access to the anchorage which they may offer.

Choice of edgewise bracket

The factors determining the choice of edgewise bracket type from among the large number of designs available will depend upon the experience and preference of the orthodontist, with cost and convenience also playing a part. This chapter should be read in conjunction with the next chapter in order to understand the intrinsic importance of the relationship between the bracket and the archwire.

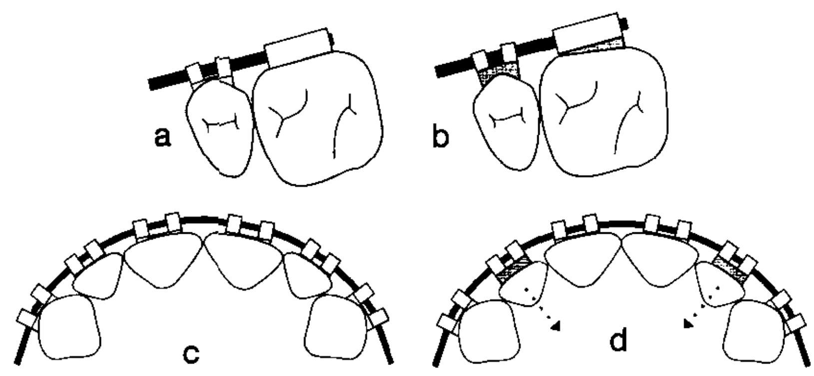

Figure 3.4 Standard and preadjusted edgewise brackets. Upper molar and premolar 'in-out' and rotation with (a) standard and (b) preadjusted brackets; upper labial segment 'in-out' control with (c) standard and (d) preadjusted brackets

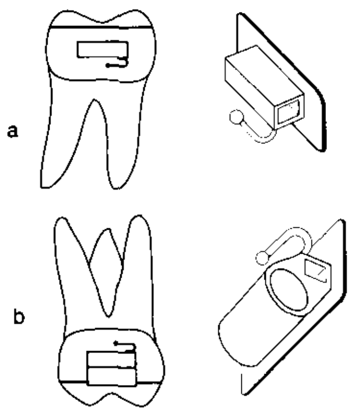

Figure 3.5 Molar band standard edgewise attachments: (a) lower right first molar with archwire tube and hook; (b) upper right first molar with archwire tube, occlusally placed EOT tube, and hook

With regard to the dimension of the bracket channel, Edward Angle, who designed the first edgewise appliances, used 0.022 in brackets – but with gold archwires. Considering the very different properties of stainless steel, 0.018 in would seem to be a more appropriate size at the present time. However, the development of new archwire materials has made the use of the larger size practicable while still applying moderate forces. The choice of channel size remains a point of controversy, with personal preference continuing to play a large part.

Channels of 0.022 in will accept the largest archwire sizes, which may be of advantage in producing precise tooth positioning. However, thick archwires are relatively inflexible, and there is the danger of applying excessive forces. When 0.022 in brackets are used with archwires of smaller size, some control of tooth position is inevitably sacrificed because of the loose fit of the archwire in the channel. Furthermore, when the archwire is a loose fit in the channel, the movement of teeth along the archwire is impeded by binding (Chapter 4). Some orthodontists consider 0.018 in the ideal channel size when used with the size and design of archwire which they prefer, accepting the inability of these brackets to accommodate the largest archwire sizes.

In regard to the mesiodistal channel width, wider brackets facilitate rotation and uprighting (Figure 3.6).

When, as is usually the case, the archwire does not fit the bracket channel precisely, the bracket has a degree of freedom to move on the archwire. For a given archwire size, this freedom is determined by the bracket channel width, and is at its least when wide brackets are used (Figure 3.6). Wide brackets allow a greater degree of control over rotation and uprighting.

On the other hand, the use of wide brackets inevitably reduces the inter-bracket distance so that the range of action of the archwire is also reduced. However, most orthodontists prefer to benefit from the greater ease of control offered by wider brackets, and to maximize the range of action by careful choice of archwire material and design.

The quality of result obtained when using a fixed appliance is dependent upon precise positioning of teeth. Preadjusted edgewise brackets

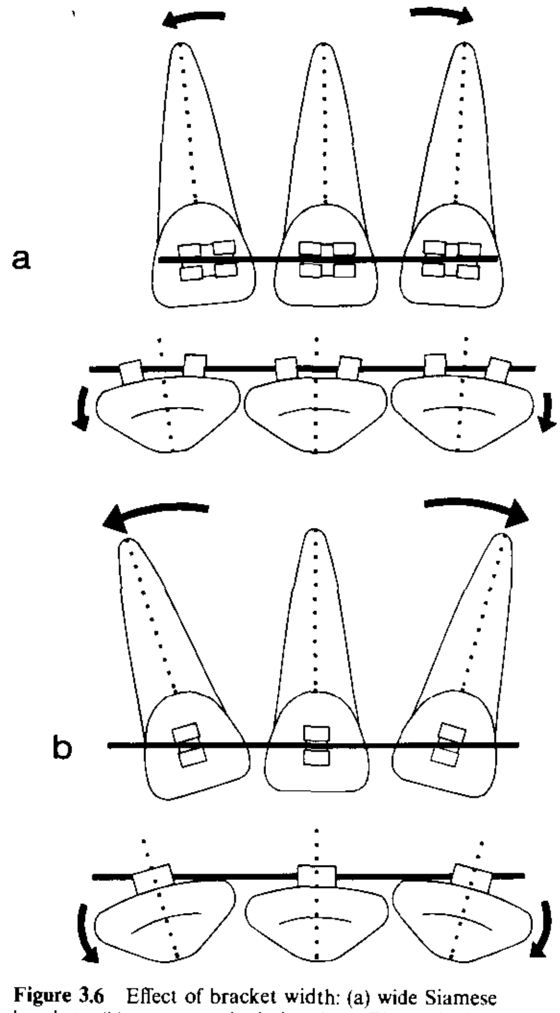

Figure 3.6 Effect of bracket width: (a) wide Siamese brackets; (b) narrower single brackets. The archwire channel size is the same. The narrower bracket allows a greater freedom of tip and rotation

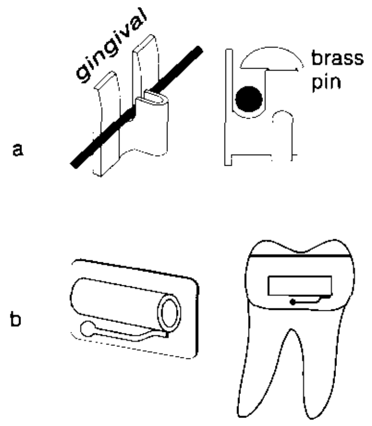

Figure 3.8 Begg brackets: (a) incisor, canine and premolar brackets; (b) molar bracket with round buccal tube and hook

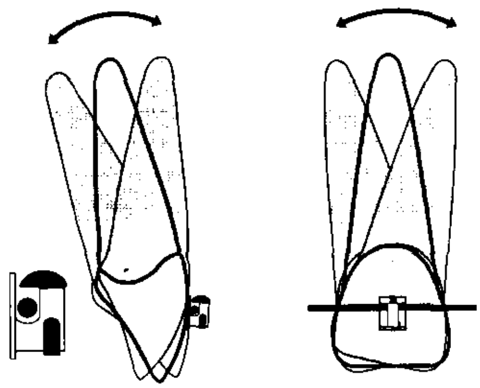

Figure 3.9 Begg bracket and archwire combination. The tooth can tip around and along the archwire

Begg brackets and archwire combinations

The Begg bracket has minimal mesio-distal width, and the archwire is a loose fit in the bracket. The consequences of the bracket and archwire combination imply a fundamental difference between the mechanics of Begg and edgewise appliances (Figure 3.9).

With Begg brackets and a plain archwire, it is not possible to generate forces actively to upright or torque teeth. The narrowness of the bracket makes precise control of rotations difficult. Accessory springs must be added to produce apical movement, and springs or elastics are sometimes necessary to produce tooth rotation.

An advantage of this approach is that the looseness of the archwire in the bracket means that the teeth are as free as possible to tip along and around the archwire. Rapid initial correction of tooth displacement is obtained while applying much lighter forces than those required by edgewise systems, with minimum strain placed upon the intra-oral anchorage. Extra-oral anchorage is therefore usually not required. Later in the treatment, when attention must be paid to apical positioning and rotation, accessory springs and archwire modifications are used (Plate 4).

A disadvantage of this technique is that, in the later stages of treatment, the appliance becomes complicated because of the need to add accessories. A consequence of the loose relationship between the archwire and the bracket is that it is difficult to hold teeth precisely in position, and unwanted tooth movements may arise.

Begg brackets are used in a comprehensive diagnostic and treatment routine - the 'Begg Technique'. As with edgewise appliances, safe use of the Begg technique requires adequate clinical training and experience.

When comparing edgewise and Begg appliances, there is no doubt that each system has advantages and disadvantages. Begg brackets enable the achievement of rapid initial alignment using light forces which place low demands upon anchorage. The technique becomes complicated and difficult to manage in the later stages of treatment. Edgewise systems demand higher force application, and are uneconomical in terms of intra-oral anchorage management. The Begg technique has become less popular than edgewise bracket based systems, particularly the preadjusted appliances. The Begg bracket is considered here principally to illustrate the contrast between two fundamentally different mechanical approaches.

Several attempts have been made to design a bracket combining the advantages of Begg and edgewise appliances. Approaches have been made both by modifying edgewise brackets to be capable of offering a narrow channel early in treatment, and by modifying Begg brackets to carry a preadjusted edgewise channel for use towards the end of treatment. No doubt further improvements in design will reflect the search for an ideal orthodontic bracket system.

Bracket materials

Metal brackets are constructed from stainless steel by casting and precise machining.

Materials offering better aesthetic properties than metals are used for the production of incisor, canine and premolar bonding brackets. Plastic brackets have the disadvantage of becoming stained, and tend to either break or distort in clinical use. Ceramic brackets are available in a range of designs for both edgewise and Begg appliances. They are manufactured either from a single large crystal by machining, or from a polycrystalline powder by the process of injection moulding. They are resistant to distortion or staining, but have a number of disadvantages when compared with metal brackets (Plate 5):

1. They may fracture in use. The brittleness of ceramic materials leads to breakage.
2. Their abrasion resistance is superior to that of tooth enamel, so they must not be placed in situations where opposing teeth are in occlusion with them.
3. Their friction properties, when used with metallic archwires, are such that sliding along the archwire is impeded.
4. Their resistance to bending and their tendency to fracture makes their removal at debonding more difficult than is the case with metallic brackets. There is an increased risk of enamel damage.
5. They are more expensive than the equivalent metal brackets.

Other attachments

In addition to brackets and molar tubes, there are a number of attachments which provide additional points of attachment for elastics and tie ligatures. Hooks, cleats, buttons and eyelets may be welded to bands, or directly bonded to the teeth (Plate 6). They are particularly useful on severely displaced or partially erupted teeth, when it may not be possible to fit a bracket in the initial stages of alignment. When space permits, careful placing of the attachment will facilitate the intended tooth movement.

Lingual mechanics

The pursuit of more aesthetically acceptable orthodontic appliances has led to the development of fixed appliances which use brackets bonded to the lingual surfaces of the teeth. Lingual orthodontics implies more than the simple transference of buccal technology to the lingual. The mechanism must avoid, as far as possible, irritation to the tongue and neighbouring tissues. Specific bracket designs are required for lingual use (they are available in edgewise, Begg and combination forms). The difficulty of accurate bracket positioning makes an indirect bonding technique indispensable, so experienced laboratory support is vital.

The inter-bracket span is inevitably reduced compared with that seen with buccal appliances. As a consequence, archwires of relatively low stiffness must be used. Space restriction makes the use of vertical loops difficult. Archwire design must take into account the different point of application of the force in relation to the centre of resistance of the tooth. The maintenance of the appliance is considerably more time-consuming for the orthodontist.

The availability of buccal attachments with improved aesthetics has reduced the justification for the more difficult lingual approach. We would advise only the experienced orthodontist to use lingual mechanics.

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4

Archwire and accessories

The archwire, by virtue of its mechanical interaction with the bracket channels, provides a means of influencing the positions of individual teeth, and of determining the overall shape of the dental arch.

'Active' archwires are analogous to the springs of removable orthodontic appliances. The energy stored by archwire deformation represents a reservoir of force which can then be used to produce tooth movement.

Accessory springs and elastics are active components used in conjunction with archwires. In this situation the purpose of the archwire is to prevent the uncontrolled movement of teeth which would otherwise occur. The archwire is then described as 'passive' or as a 'base archwire'.

The distinction between active and passive is a useful point at which to begin a consideration of archwire design and use, but in clinical practice an archwire will often need to satisfy both functions in its relationship to teeth in different parts of the dental arch. A characteristic of fixed appliances is their ability to achieve a number of complex tooth movements simultaneously. The potential can only be achieved safely by careful use and design of archwires and accessories. This chapter outlines the general principles, and the reader is referred to later chapters for more detailed consideration of specific clinical use.

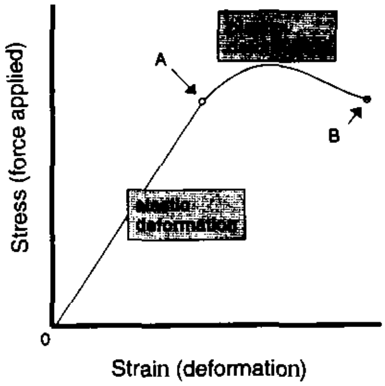

Figure 4.1 Elastic properties of wire: (a) elastic limit; (b) breaking point

Elastic properties of wire

When a load is applied to a wire, the wire will bend. The amount of bending is referred to as strain, expressed in units of length. As the load is increased and the stress (force per unit cross-sectional area) on the wire rises, the wire deforms elastically until the elastic limit is reached (Figure 4.1). With stainless steel wire the amount of bending produced is directly proportional to the load applied (Hooke's Law). Stress/strain is a constant known as the Young's Modulus for that particular wire. A wire which has been deformed elastically will return to its initial shape if the load is removed.

If the wire is stressed beyond its elastic limit further bending will occur, but now the wire will take on a permanent 'set', and will no longer return to its initial shape if the load is removed. Deformation accompanied by permanent bending is referred to as plastic deformation. Further stressing will result in breakage of the wire.

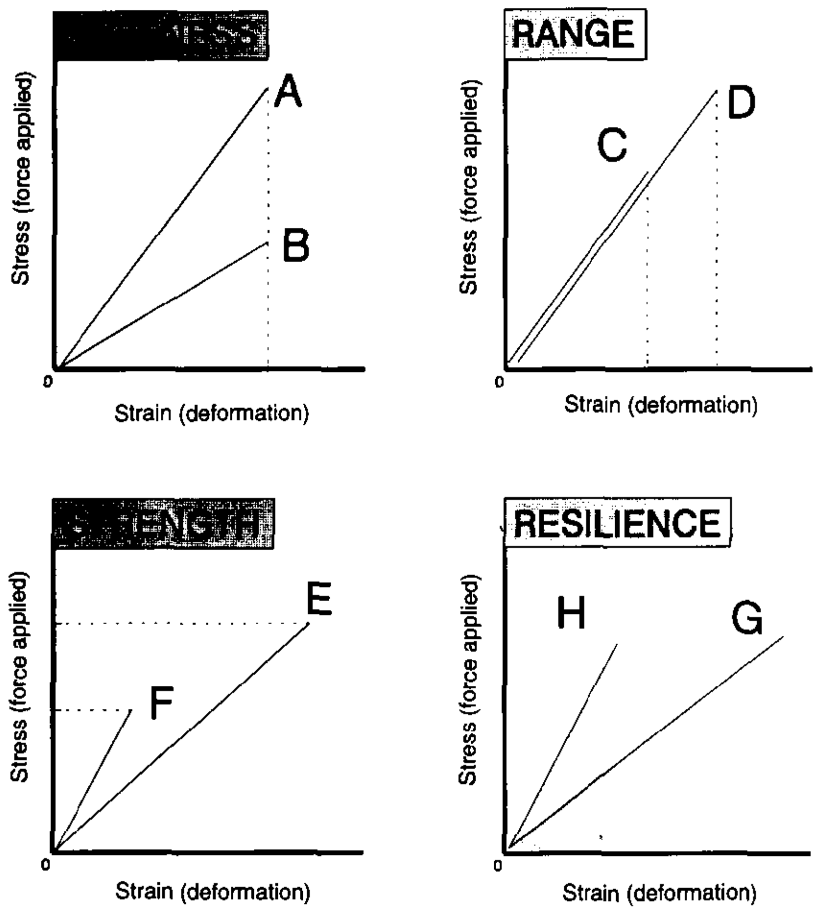

Figure 4.2 Stiffness, range, strength and resilience of wires

Stiffness

Stiffness is a measure of the wire's resistance to bending. Referring to Figure 4.2, wire A is stiffer than wire B, so that for a given deflection it will deliver a greater force. Stiffness is represented by the slope of the graph (Young's Modulus). The stiffness of a wire indicates the rate at which it delivers force, but does not indicate the maximum force which it could deliver, nor the range of deflection of which it is capable. Wires A and B, although differing in **stiffness**, have identical **range**.

Range

Range (or working range) is a measure of how far the wire can be deflected within its elastic limit. In Figure 4.2, wire D has a greater **range** than wire C although their **stiffness** is identical.

Strength

Strength is a measure of the maximum force which can be applied by the wire at the upper limit of its elastic range. In Figure 4.2, wire E has greater **strength** (and range), but less **stiffness** than wire F.

Resilience

Resilience is a measure of the force storage capacity of the wire, and it is represented by the area beneath the graph. In Figure 4.2, wire G has greater resilience than wire H. The two wires have identical **strength**, but wire G has greater **range** than wire H.

The three elastic properties of archwire materials which are of greatest importance are stiffness, range and strength.

It is important to recognize that stiffness,

range and strength are independent variables which do not vary in proportion. They are related to the composition, size and configuration of the wire, and they will determine the choice of archwire for use in a given clinical situation.

The behaviour of an archwire

The behaviour of an archwire depends upon:

- the diameter of the wire;
- the composition of the wire;
- *the length and configuration of the inter-bracket span;*
- the width of the brackets;
- friction between the wire and the bracket channel.

These factors will now be considered in more detail:

The influence of wire diameter

Consider two round wires of the same composition, one having a diameter of 0.3 mm and the other a diameter of 0.6 mm and each supported between two points separated by the same distance (Figure 4.3).

In order to apply a given force in the centre of the span, the thinner wire must be deflected 16 times further than the thicker wire (assuming elastic deformation in both cases). The relevant relationship is that the force applied (which is dependent upon the **stiffness** of the wire) is proportional to the fourth power of the wire diameter. Expressed in a different way, doubling the wire diameter means that in order to deliver the same force, the wire needs to be deflected by only one-16th of the distance. Wire diameter is therefore a very important determinant of the characteristics of an archwire, and small changes in archwire diameter have a disproportionately large influence on the forces applied.

The relationship between the force applied by a wire (in elastic deformation) and its **length, diameter and amount of bending** is expressed in the following **General Formula**:

$$\text{Force is proportional to } \frac{D \times R^4}{L^3}$$

where D is the amount of deformation or bending (expressed for example in millimetres), R is the radius (or diameter) of the wire, and L is the length of the wire.

The force applied is directly proportional to the amount of bending – a reflection of the graphs in Figure 4.2.

The force applied is directly proportional to the fourth power of the diameter of the wire, and inversely proportional to the third power of the length of the wire.

The diameter of round wires most commonly used for archwire fabrication are listed here, together with their nearest metric equivalent:

0.012 in (0.3 mm)
0.014 in (0.35 mm)
0.016 in (0.4 mm)
0.018 in (0.45 mm)
0.020 in (0.5 mm)
0.022 in (0.55 mm)

A useful guide for clinicians is that each increase in archwire size in this range approximately **doubles** the force applied for a given deflection compared with the preceding size (assuming of course that the wires are of the same composition).

Changing wire diameter also affects, to a lesser extent, both strength and range. Strength is proportional to the third power of the diameter. Doubling the diameter increases strength by a factor of eight so that at maximum deflection the force generated by the wire will increase by a factor of eight. Range is inversely proportional to diameter, so doubling the diameter halves the range, and the wire can only be bent half as far

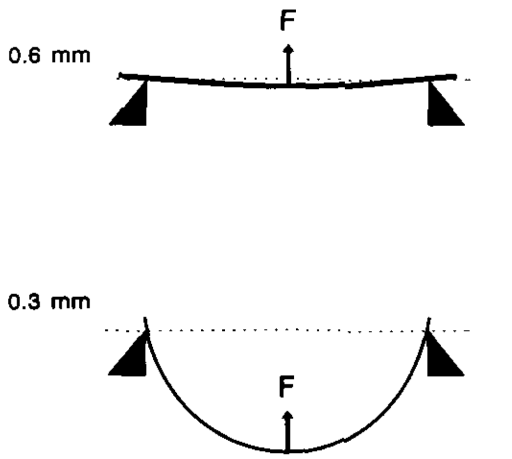

Figure 4.3 The influence of wire diameter. The 0.3 mm diameter wire must be deformed 16 times further than the 0.6 mm diameter wire in order to deliver the same force at the centre point of the span

before attaining its elastic limit and taking a permanent 'set'.

With rectangular wire, there is a greater choice of dimensions than in the case of round cross-section wire. In addition, rectangular wires may be used either 'edgewise' (with the maximum dimension horizontal) or 'ribbonwise' (with the maximum dimension vertical). The dimensions of the wire, as in the case of round wires, have a very significant effect upon the behaviour of the archwire. Whether a particular wire size is used 'edgewise' or 'ribbonwise' also affects the elastic properties. If a rectangular wire is used 'edgewise', its stiffness is greater in the horizontal than in the vertical plane.

As a rough guide, the stiffness of 0.016 × 0.016 in rectangular wire is approximately equivalent to that of 0.018 in round wire, assuming that composition is identical. Rectangular wire of 0.016 × 0.028 in when used 'edgewise' in bending has approximately two and a half times the stiffness of the **thickest** round wire in common use (0.022 in). There is clearly a danger of applying excessive forces when rectangular archwires are used.

A further complication arises in that rectangular wire can be used to deliver force both in longitudinal bending as described above, and in torsion (twisting). The relationship between edgewise brackets and a rectangular archwire in torsion allows torqueing forces to be delivered to the teeth. If preadjusted brackets are in use, the insertion of a plain rectangular archwire activates the torque programmed into the brackets. The effects of wire dimension again have a considerable influence over the force applied for a given torsional deflection. The inexperienced operator will find great difficulty in assessing these forces, and there is again the danger of excessive force application.

The influence of wire composition

'Heat-treated' or 'high-tensile' stainless steel is the most widely used material. Its elastic properties make it well suited for use as an archwire material, and it has the advantage of availability in a wide range of sizes at relatively low cost. Stainless steel wire is also produced in a braided form, with up to six or more separate wires making the 'multistrand' archwire material. Multistrand wire has the advantage of considerably reduced stiffness and increased range as compared with a single-strand wire of the same diameter and composition. Round multistrand wire finds its main application early in treatment, when there are marked tooth displacements within the arch. Rectangular multistrand wire may be used at the stage of transition from round wires to rectangular single-strand wires in edgewise brackets.

'Nickel-titanium' archwire (e.g. 'Nitinol') is made from an alloy of nickel, titanium and cobalt. It is available in preformed archwire shape and in straight lengths, and its elastic properties make it particularly appropriate for use early in treatment when individual tooth displacement is at a maximum. Its advantages over single-strand stainless steel are much reduced stiffness, and an increased range. In these respects it is similar to multistrand stainless steel wire, but nickel-titanium has a larger range, and is less liable to plastic deformation arising from occlusal forces.

Nickel-titanium wire, unlike stainless steel, does not obey Hooke's Law. With small deformations the stress/strain slope (Figure 4.1) is relatively steep, but further deformation produces a marked flattening of the slope followed by a further steepening leading to the elastic limit. The relatively flat portion of the slope is large in extent, and indicates the possibility of applying nearly constant force over a large range of deformation.

Nickel-titanium is more expensive than stainless steel, and has the disadvantage of brittleness, so that it may fracture in use. It is difficult to bend without fracturing (low formability), so it is generally used as commercially preformed archwire.

More recently 'Austenitic' as opposed to 'Martensitic' nickel-titanium wires have become available ('Ni-Ti'). These 'super elastic' wires have the unusual property of changing their phase from Austenitic to Martensitic when deflected. Their elastic properties change favourably in terms of stiffness by being deflected into the brackets. The stress/strain slope is relatively flat, so that they apply a constant force over a large range. They can be deformed over large distances without applying excessive forces or taking a permanent 'set'.

Beta-titanium archwire ('TMA') is made from an alloy of titanium, molybdenum, zirconium and tin. Beta-titanium wire may be used at the commencement of treatment to produce initial alignment, but it has an inferior range and greater stiffness when compared with Nickel-titanium.

On the other hand it has superior formability. Its characteristics make it particularly appropriate in its larger sizes as a finishing archwire towards the end of treatment. Rectangular Beta-titanium archwires of 0.021 × 0.025 in, which almost completely fill a 0.022 in bracket channel, are useful for final detailing of tooth position. Stainless steel wire of this size is very stiff, and there is a danger of applying excessive force. Nickel-titanium wire of this size is insufficiently stiff for effective torque detailing.

Elgiloy is a chromium-nickel-cobalt alloy which can be used for the construction of archwires. It can be formed into an archwire in the 'soft' state, and then used in that form to apply light forces. Alternatively, it can be 'hardened' by heating to increase its stiffness. It is doubtful, in view of the availability of other archwire materials, whether the inconvenience of heat treating Elgiloy can be justified.

The length and configuration of the inter-bracket span

Consider two wires of the same size and composition, and supported between two points. The deflection required to produce a given force at the centre of the span depends upon the distance between the supports (Figure 4.4).

Referring to the **General Formula** above, force is inversely proportional to the third power of the length. If the distance between the supports is doubled then the deflection required to produce a given force is increased by a factor of eight.

In clinical terms, the length of the archwire between adjacent brackets has an important bearing on the stiffness of the archwire. Relatively large inter-bracket spans allow a relatively large length of archwire to lie between the brackets. The force delivered to the teeth will then be low compared with that seen with a small inter-bracket span, and the range of action of the archwire will be enhanced. This is the situation when Begg brackets are used.

When wide (Siamese edgewise) brackets are used, the length of the inter-bracket span is inevitably reduced. In addition, the archwire within the bracket channels is constrained. Reduction in archwire stiffness or the incorporation of loops (to increase the length of wire in the span) may need to be considered in order to increase the flexibility of the archwire.

The length of wire between adjacent brackets can be significantly increased by the incorporation of loops. Vertical loops are useful for increasing flexibility in a buccolingual direction and for dealing with rotated teeth (Figure 4.5).

Careful design and activation of vertical loops will also enable limited mesiodistal movement of teeth to be achieved, and they are of particular use when dealing with localized incisor rotation and crowding.

Vertical loops are much less flexible in vertical displacement than in horizontal displacement. A modification of the inter-bracket archwire span to form horizontal loops is possible. However, it is both easier and more efficient to deal with vertical displacements either by using a plain archwire of low stiffness, or by commencing the movement of teeth with marked vertical displacement by applying elastic traction from a rigid 'passive' archwire.

The introduction of low stiffness wires (particularly those manufactured from nickel-titanium

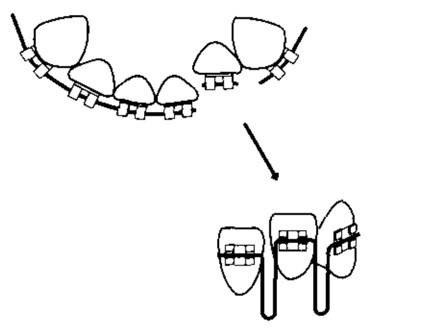

Figure 4.5 Vertical loops used to rotate and move a lower incisor labially

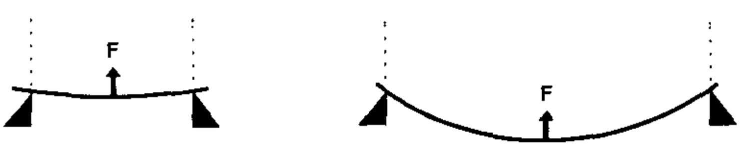

Figure 4.4 The influence of wire length. Doubling the distance between the supports means that the wire must be deflected eight times further in order to deliver the same force at the centre point of the span

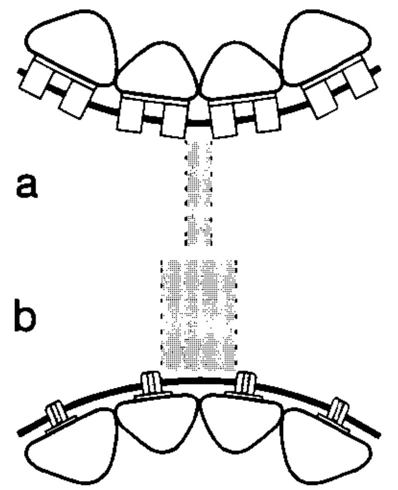

Figure 4.6 The influence of bracket width on inter-bracket span: (a) Siamese edgewise brackets; (b) Begg brackets

alloys) has to a large extent eliminated the need for archwires carrying multiple vertical loops. Multilooped archwires are time-consuming to prepare, are more difficult to keep clean in the mouth, and may impinge upon the neighbouring soft tissues.

The influence of bracket width

Brackets place constraint on the wire lying in the archwire channel, and so affect the degree of activation of the inter-bracket archwire span (Figure 4.6). The constraint is at a minimum when narrow (Begg) brackets are in use. Wider (edgewise) brackets place more constraint upon the archwire, although the effect is less with narrow edgewise brackets than when the widest (Siamese) brackets are used. The effects are complex, and depend upon the precise alignment of the teeth.

The influence of friction

Friction between the archwire and the bracket channel becomes an important consideration when a tooth is moved **along** the archwire. Movement of a tooth in this manner is referred to as 'sliding mechanics', and is to be contrasted with 'closing loop mechanics' in which a tooth **and the archwire** move together as a unit (Figure 4.7). In sliding mechanics the retraction force is provided by an accessory, for example a latex elastic ring. In closing loop mechanics the archwire itself is adapted to provide the longitudinal elasticity required for retraction.

In Figure 4.7(a), an active 'sectional' archwire is attached to the molar, premolar and canine. The canine moves distally without dissipation of the retraction force in frictional losses between the archwire and the canine bracket. In Figure 4.7(b), however, the retraction force must overcome friction as the canine bracket moves distally along the archwire. The retraction force is provided by the elastic, and the archwire is passive.

The force which is required to overcome friction is in clinical practice impossible to quantify accurately. It will vary as the canine bracket channel changes its angulation to the archwire during retraction. Forces arising from friction between bracket and archwire in sliding mechanics may be sufficient to produce 'bracket binding', which prevents favourable tooth movement.

Frictional forces rise when a rectangular wire fits the channel precisely. It is suggested that a clearance of at least 0.003 in between the bracket channel and the archwire is required for sliding mechanics.

When stainless steel archwires of the smaller dimensions are in use, frictional forces may increase because the amount of friction is influenced by the contact angle between the archwire and the bracket. In Figure 4.8(a), the use of an archwire which is of insufficient diameter (for example, 0.012 in) allows tipping of the canine so that the contact angle increases, and bracket binding may occur. In addition, low wire stiffness will allow deformation of the

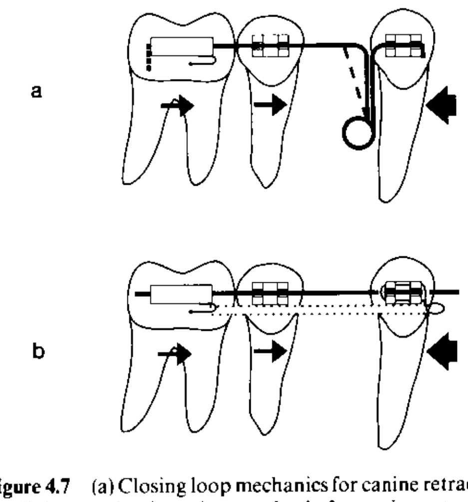

Figure 4.7 (a) Closing loop mechanics for canine retraction; (b) sliding mechanics using an elastic for canine retraction

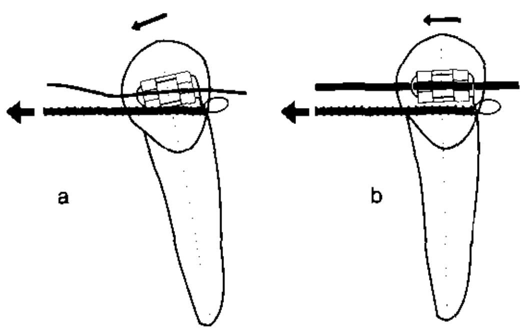

Figure 4.8 Sliding mechanisms and frictional forces: (a) archwire of insufficient diameter allows tipping, and frictional forces rise; (b) archwire size closely matches archwire channel, tipping is restricted, and frictional losses are reduced

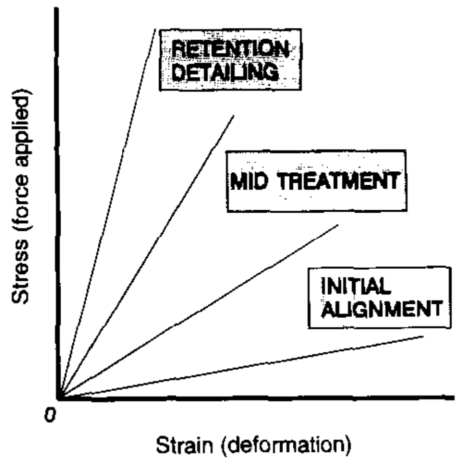

Figure 4.9 Archwire choice at different stages of treatment

archwire with further loss of control over canine retraction. As a guide, a 5° contact angle doubles, a 10° angle triples, and a 20° angle quadruples the friction. Bracket binding can be minimized by using an archwire size which more closely matches the archwire channel, while allowing at least 0.003 in clearance. Stainless steel wire with an occluso-gingival dimension of 0.019 in is ideal when 0.022 in edgewise brackets are in use. Nickel-titanium archwires, particularly round wires, are insufficiently stiff to prevent undesirable tipping.

In order to minimize friction, a loosely applied stainless steel ligature is to be preferred to a tight elastomeric bracket elastic.

Friction forces are at a minimum when Begg brackets are used, because of the freedom of the archwire to move in the bracket channel. Rapid initial improvement in alignment (by tipping) is seen with the application of light forces.

The magnitude of frictional forces is also influenced by archwire and bracket composition. Beta-titanium archwire generates relatively high frictional forces and is not ideal for sliding mechanics. Ceramic brackets generate relatively high frictional forces when in contact with metallic archwires.

The choice of archwire in the clinical situation

The demands placed on the archwire depend upon the particular purpose for which it is intended, and the purpose will change at different stages of treatment. No single archwire can satisfy all the requirements of treatment.

For each archwire, stiffness must be such that an appropriate force magnitude is delivered, strength must be sufficient to prevent distortion by masticatory forces, and range must make it possible to apply the force over a sufficient distance, so that frequent reactivation is not required.

The archwire must be resistant to fracture, and of a material which is safe to use in the mouth.

In order to provide a general guide to archwire choice, three distinct treatment stages can be identified:

- *initial alignment;*
- mid-treatment;
- detailing and retention.

Figure 4.9 illustrates general principles of archwire choice at the different stages of treatment.

Archwires for initial alignment

At the beginning of treatment the aim is to achieve initial resolution of labiolingual displacement, rotation and apical displacement, and to begin the process of 'levelling', with reduction of discrepancies of individual tooth position in the horizontal plane.

Early in treatment, tooth displacement will be at its greatest. The principal archwire requirement is for minimum stiffness and maximum range, in order that the archwire can apply force of appropriate magnitude over relatively large distances.

Detailed control of tooth position is sacrificed in order to achieve 'unravelling' of crowded teeth.

The archwires used in the initial stages of treatment are designed to enable full engagement of the archwire in the bracket channel at the earliest opportunity.

Archwire materials appropriate for the initial alignment stage are round cross-section wires as follows:

1. nickel-titanium (preferably in its 'super elastic' form);
2. multistrand stainless steel.

Where tooth displacements are marked, and wide (Siamese edgewise) brackets are in use, the first archwire should be particularly low in stiffness and high in range. 'Super elastic' nickel-titanium wire of 0.012 in diameter, or six-strand multistrand stainless steel wire of 0.015 or 0.0175 in diameter may be chosen. The nickel-titanium wire offers the greatest working range, so that it will remain active for a longer period, and it is more resistant to distortion in the mouth. Friction forces are lowest in the case of nickel-titanium, but it has a greater tendency to fracture.

When there are marked individual tooth displacements, it may be necessary loosely to ligate the bracket to the archwire (rather than attempting to achieve full bracket engagement), in order to avoid excessive archwire deformation and to limit the force applied. An important principle is to have achieved full engagement of the archwire in all the bracket channels before moving up to the next archwire size.

The next archwire progression could be to 0.014 in or 0.016 in diameter nickel-titanium, or to 0.0175 in diameter multistrand stainless steel. If 0.018 in edgewise brackets are in use, 0.0175 in multistrand wire is not ideal, because the small clearance between the archwire channel and the archwire will restrain movement of the archwire through the channel. Even larger diameter nickel-titanium or multistrand round wires may be used to complete the period of initial alignment.

The very nature of initial alignment archwires means that they offer poor control over unwanted tooth movements. Their low stiffness means that it is inadvisable to use them in combination with elastic traction, because they will allow too much tipping of (otherwise unsupported) anchorage units. Sliding mechanics, using elastic traction or coilsprings for instance, should be avoided because of bracket binding and because the archwire is likely to bend, with loss of angular control over both the teeth being moved and the anchorage units.

The wires for initial alignment are used in the form of commercially preformed archwires (nickel-titanium) or, in the case of multistrand wires, in straight lengths. In other words, little or no attention is paid to individualized archwire form (Chapter 6). Because of their low stiffness, they have no appreciable detrimental effects in this respect, providing they are used only for a short period.

In most cases, initial alignment is complete within three months of commencing treatment. Indeed, considering the poor control offered and the dangers of producing unwanted tooth movement, initial archwires should be exchanged for the archwires of mid-treatment as soon as possible – **remembering the rule of achieving full bracket engagement in all the bracket channels before moving up to an archwire of increased stiffness**.

Mid-treatment archwires

In the mid-treatment stage, the highly flexible archwires used for initial alignment are replaced by a series of 'working' archwires of increasing stiffness, offering progressively greater control over tooth position.

In the early stages of mid-treatment single-strand, round, stainless steel archwires of small diameter are appropriate (for example 0.014 in). The incorporation of one or two vertical loops can be of assistance where significant local tooth displacement remains.

Archwires of 0.016 in and then 0.018 in diameter are used next (still remembering the rule of achieving full engagement of the archwire in the bracket channels before moving up to the next size).

If movement of teeth **along** the archwire is required (sliding mechanics), then the archwire must be capable of adequate control of tooth position, and frictional losses must be kept as low as possible. When round wire is used then it should be of **at least 0.016 in diameter** (0.018 or 0.020 in is preferable with 0.022 in brackets).

With wide (Siamese) edgewise brackets there is a low contact angle between the archwire and the bracket, and therefore less friction when compared with narrow edgewise brackets. Bracket binding (Figure 4.8) is more likely to occur when the smallest wire diameters are used with 0.022 in edgewise brackets. Even when the largest arch-

wire sizes are used, true 'bodily' movement of teeth will not be seen unless adjustments are made in the archwire to compensate for the tendency of teeth to tip in the direction of the applied force as they are moved along the archwire. Begg brackets offer minimal friction with the archwire, but the teeth are free to tip around and along the archwire, and accessory springs must be used at a later stage to correct tooth angulation.

Blocks of teeth, or individual teeth, may also be moved **with the archwire** rather than along it (closing loop mechanics, see Figure 4.7).

Mid-treatment archwires are sufficiently stiff to enable the molars to resist unwanted movement, and they therefore play an important part both in molar control and in anchorage management. Inter- and intra-maxillary elastic forces (see below) can be used safely with stainless steel single-strand round wires of 0.016 in diameter and above.

During mid-treatment, attention must be paid to continuing the uprighting and rotation of teeth which was commenced in the initial alignment stage. Overbite and overjet are corrected, and spaces closed. Vertical or horizontal 'bayonet' bends in the archwire will enable detailed correction (and over-correction) of rotations, angulation in the line of the arch, and vertical position (Figure 4.10).

If edgewise brackets are in use, and it is intended to progress to rectangular wire, the use of round wire as described above is to be recommended in the first instance. As an intermediate stage, it may be of advantage to step down to rectangular wires of low stiffness (multistrand, nickel-titanium or Beta-titanium)

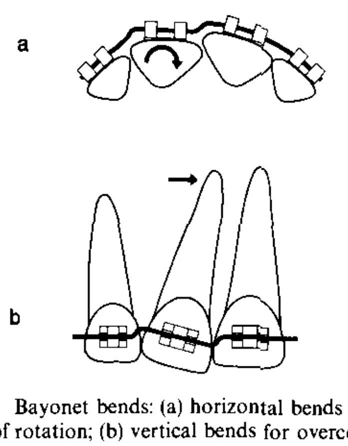

Figure 4.10 Bayonet bends: (a) horizontal bends for overcorrection of rotation; (b) vertical bends for overcorrection of apical position

before using single-strand stainless steel rectangular wire. Once again, the correct approach is to use a series of rectangular wires of increasing stiffness. With 0.022 in brackets nickel-titanium 0.018×0.025 in, and then 0.019×0.025 in stainless steel is an appropriate progression.

It must be remembered that, considering the relatively large stiffness of rectangular wire compared with that of round wire, there is a significant danger of applying excessive forces. In addition, any mechanism which is designed to minimize tipping, and to achieve movement of the apex of the tooth in the same direction as the crown, places considerable strain upon anchorage and extra-oral support will usually be required.

The sequence of archwire changes during mid-treatment will depend of course upon the mechanical technique being followed and the treatment aim, but the overall concept of progressive increase in archwire stiffness still applies. In mid-treatment attention must be paid to individualized archwire form (see Chapter 6), and it becomes increasingly important for the orthodontist to monitor tooth movement and possible changes in arch configuration.

Archwires for detailing and retention

When the principal tooth movements have been achieved using the mid-treatment archwires it is necessary to complete final detailing of tooth position and then to provide retention. The archwire requirements at this stage are for high stiffness and low range.

Final detailing may require the use of bayonet bends in the archwire (Figure 4.10).

If preadjusted edgewise brackets have been used then theoretically the detailing stage will be unnecessary because of the activation programmed into the brackets. However, minor errors in bracket positioning will become obvious in these final stages of treatment, and archwire modification may still be required.

When rectangular wire has been used at the end of the mid-treatment stage the detailing archwire should also be rectangular, possibly of increased stiffness, and retaining any torqueing adjustments which have been incorporated (non-preadjusted edgewise brackets). Beta-titanium archwire of 0.021×0.025 in size has a stiffness which is appropriate for final detailing of tooth position.

When only round wires have been used in

mid-treatment, then round wires of 0.020 in diameter can be used for detailing providing the bracket channel dimensions will accommodate wire of that size. It should be remembered that if round wires are used in this stage, it will not be possible to retain any torqueing movements achieved during mid-treatment unless modification of the archwire is made.

Begg brackets present problems at the detailing and retention stage. The loose fit of the archwire in the channel, and the flexibility of the accessory springs makes precise positioning of teeth very difficult to achieve and retain.

After detailing, it is usually wise to continue with the fixed appliance, because it will act as a rigid retainer. The final detailing archwire can be used during the fixed appliance retention phase.

Archwires and force magnitude

The forces applied by fixed appliances are high compared with those which have been suggested as appropriate for producing tipping movements with removable appliances. Figure 4.11 gives some indication of the sort of force magnitudes which might be encountered. Fixed appliances will need to apply greater forces to produce, for example, 'bodily' tooth movement.

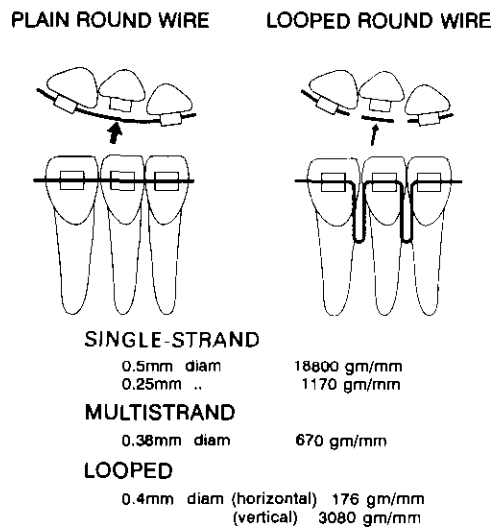

Figure 4.11 Forces applied by archwires. Stiffness is expressed as grams force for each millimetre deflection at the centre point of the span. The bracket width is 3 mm and the span width is 13 mm. For looped wire, stiffness is given for both horizontal and vertical deflection (after Waters, Stephens and Houston, 1972)

Although these forces appear to be disproportionally high, some of the force will be dissipated in friction, and some distributed to neighbouring teeth. Furthermore, teeth will immediately displace slightly within the confines of the periodontal ligament when force is applied.

Limitation of force application will also occur when the archwire is distorted beyond its elastic limit, and takes on a permanent 'set'. In this situation, however, the orthodontist is unable to predict the action of the archwire, and there is still the danger of excessive force application. Situations in which the archwire is distorted beyond its elastic limit are therefore to be avoided by choosing an archwire of appropriate design and physical characteristics.

In practice there are always a number of imponderables, so that it is impossible to provide other than general guidance in a particular clinical situation. A safe approach will entail always using the **lowest force which will achieve *the required tooth movement*.** Heavy continuous forces are in danger of damaging the teeth and their surrounding structures, and placing unnecessarily large demands upon the anchorage.

Proffit (1993) points out that it is not the force on a given tooth which is ultimately important, but the **pressure** in the periodontal ligament – in other words the force per unit area. He gives the following suggestions relating force application requirement to quality of tooth movement (figures are approximate):

Tipping:	50–75 gm force/tooth
Bodily movement:	100–150 gm force/tooth
Uprighting:	75–125 gm force/tooth
Rotation:	50–75 gm force/tooth
Extrusion:	50–75 gm force/tooth
Intrusion:	15–25 gm force/tooth

Archwires for different techniques

Each of the various fixed appliance 'philosophies' has a unique approach to bracket usage, anchorage management, and even treatment aim. These differences are reflected in archwire design. The personal preference of the operator will play a major part in determining which technique to use. A particular technique will have individual strengths and weaknesses, and experienced operators will be able to choose a mechanical

approach which is in their hands most appropriate for the malocclusion under treatment.

A major distinction lies in whether the archwire is 'continuous' (engages all the brackets in the arch) or 'segmental' (separate sectional wires, each engaging the brackets in a group of teeth). This is one of the many controversial issues in orthodontics. It is certainly possible to achieve excellent results with either mechanical approach, and there is insufficient reliable evidence at the present time to form a sound opinion as to which is to be preferred.

Accessories

The accessories which are used with archwires to produce tooth movement are elastics, coilsprings, uprighting springs, whip springs and magnets.

Elastics

Elastic is manufactured in several forms suitable for orthodontic use. Latex elastic rings are available in a range of sizes and thicknesses. Synthetic elastic polymers are also produced, in ring, chain and thread forms.

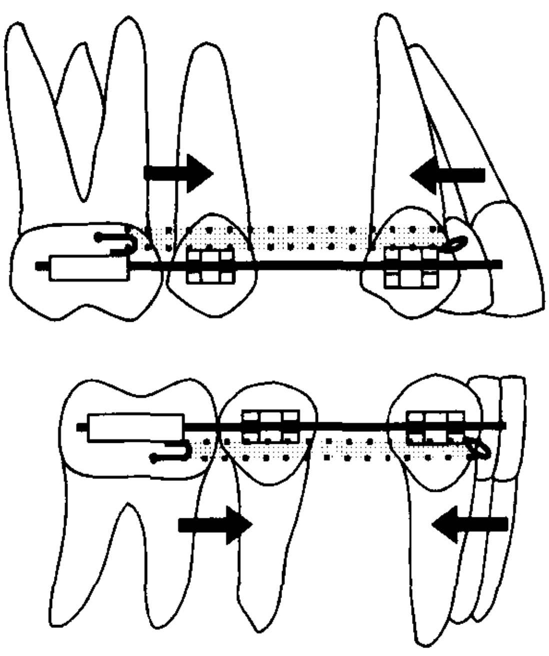

Figure 4.12 Intramaxillary elastics running between molar hooks and Kobayashi hooks on the canines

Ideally (as with all methods of force application), the force applied should be not only of an appropriate magnitude, but also at a constant level over a period of time. Unfortunately, the force delivered by elastics declines quite quickly in the mouth. Latex elastics have the advantage of being able to be changed by the patient on a daily basis, so maintaining a reasonably constant force. They should be worn continuously, except when they are removed for tooth cleaning.

Elastic thread is quick and convenient to use. It finds its main applications in space closing (sliding mechanics) and during the early stages of dealing with a severely displaced tooth, before it can be attached directly to the archwire. Thread is liable to breakage, and cannot be replaced by the patient.

Elastic chain is useful as a means of attaching a number of teeth to the archwire and maintaining them in contact. There is always a risk of applying excessive force, and ideally a tension gauge should be used to make sure that an appropriate force magnitude is being applied.

Intramaxillary traction (Figure 4.12) is the term used to describe forces applied within either the upper or lower arch. Elastic materials can be used in a variety of ways to generate intramaxillary forces. Elastic can be attached to molar hooks, or to brackets on other teeth. The possible effects on the anchor teeth must of course be borne in mind, and steps taken to prevent them from moving into unwanted positions.

It is sometimes necessary to provide a hook or ring on the archwire for attachment of one end of the elastic. If used as a point of attachment in this way, the archwire must be sufficiently rigid to avoid distortion, and to prevent unwanted movement of anchorage teeth. The archwire must be of a stiffness at least equivalent to that of 0.016 in single-strand stainless steel. When sliding mechanics is employed to move a tooth along the archwire, elastics are particularly useful. The elastic can be attached to a hook formed in the ligature on the tooth being moved – a 'Kobayashi ligature', as shown in Figure 4.12.

If an elastic is applied to a single tooth which is not attached to the archwire (a severely displaced tooth) the force magnitude should be in the range 50–80 grams, depending upon the size of the tooth root. In this situation the tooth will be free to move without the influence of an archwire, and the force must be kept particularly light.

With sliding mechanics, the most appropriate

force to use will depend upon a number of factors, all impossible to measure with accuracy, and likely to change as the tooth moves. Friction between the archwire and the bracket channel, the degree of tipping allowed, the size of the tooth root and occlusal forces are some of the factors making it impossible to specify the force precisely. The orthodontist should always employ the lowest force which will produce the tooth movement required. When edgewise brackets are in use, sliding mechanics applied to a single canine tooth should begin with a force of 80 grams, only increasing the force, step by step, if tooth movement is absent. Remember that there are many reasons for failure of tooth movement, and insufficient magnitude of force application is only one of them! Before increasing the force, check the more likely reasons for failure of movement – in this situation, mechanical obstruction or intermittent application of the elastic force.

Begg brackets place the least constraint on a tooth moving along the archwire, and much lighter forces are required to produce tooth movement. If an uprighting spring is attached to the bracket however, tipping may be entirely prevented, and a much larger force will need to be applied to produce movement of the tooth.

Intermaxillary traction is the term used to describe the use of elastic stretched between the upper and lower arches (Figure 4.13). Latex elastic rings are used for this purpose. Intermaxillary traction enables tooth movement to be achieved in one arch with anchorage derived from the other arch. Its effect depends upon the site of attachment of the elastics and their line of action. Class II traction involves the attachment of elastics anteriorly in the upper arch and posteriorly in the lower. Depending upon the upper archwire configuration, class II traction can provide a distal force to the whole upper arch, preventing forward movement of the upper buccal teeth, or it may be used to reduce the overjet by moving the incisors in a palatal direction. The reaction in the lower arch is to move the buccal teeth forwards, possibly closing extraction spaces. Class II traction carries the danger of moving the lower incisors labially into an unstable position. Class III traction involves the attachment of elastics posteriorly in the upper arch and anteriorly in the lower. The design of the lower archwire will determine whether the traction will apply a distal force to the lower incisors, or to the whole lower arch. Class III traction will, in the upper arch, move the molars forwards, and this can be used to procline the upper incisors or to close extraction spaces. As a general rule, class III traction is used in the treatment of Class III cases.

Again, because of the large number of factors which cannot be measured accurately, it is not possible to suggest other than a fairly wide range of force magnitude. A force of 60–100 grams on each side (when the teeth are in occlusion) is appropriate, with the lowest forces being used

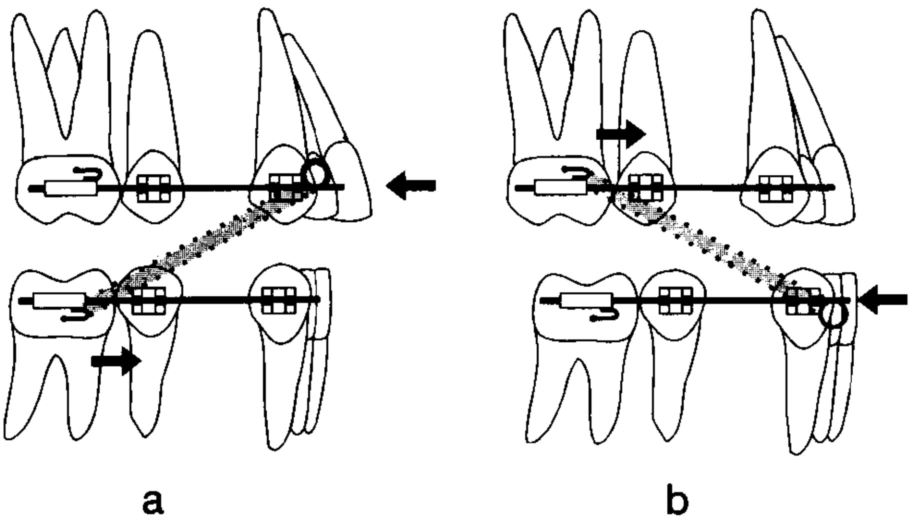

Figure 4.13 Intermaxillary traction: (a) Class II traction between lower molar hook and upper archwire hook; (b) Class III traction between upper molar hook and lower archwire hook

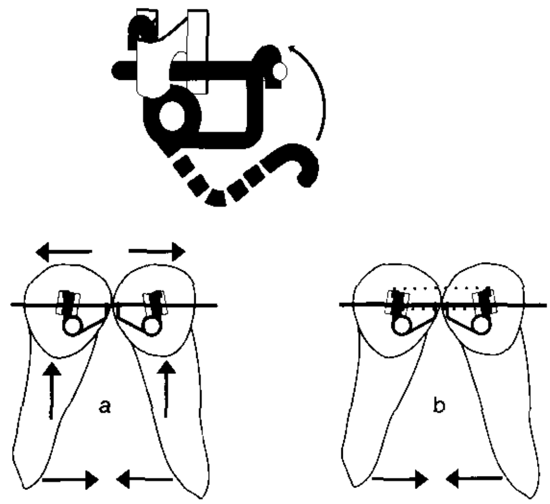

Figure 4.14 Begg uprighting springs: (a) the springs will move the apices together, but the crowns apart; they will also move the teeth occlusally; (b) the crowns of the teeth are tied together, and the springs are adapted to prevent the teeth moving occlusally away from the archwire

with Begg brackets. It is most important for elastics to be worn full time except when removed for tooth cleaning. They should be replaced daily, or immediately if they break.

The use of intra- and intermaxillary forces is discussed in more detail in Chapter 8.

Coilsprings

Coilsprings are made from hard, stainless steel, round wire, or from nickel-titanium wire. The nickel-titanium types have particularly favourable elastic properties, with low stiffness and large range.

Coilsprings can be threaded onto the archwire before ligation, and employed in their compressed form between adjacent brackets as 'pushcoils'. In this way they are used as the active component for sliding mechanics, when teeth are being moved along the archwire. They are particularly useful for opening space (Plate 7), but they can also be used as the active component for tooth retraction.

Nickel-titanium coilspring modules can be used as 'pull coils' in the place of intramaxillary elastics. They offer the advantage of nearly constant force application over a large range.

Uprighting springs and whips

Uprighting springs (Figure 4.14) are used with brackets incorporating a vertical slot (for example, Begg brackets) to produce apical movement in a mesiodistal direction. One end of the spring is accommodated in the vertical pin channel of the bracket, and the other end is formed into a hook which engages over the archwire. The action of engaging the spring tensions the coil. The reciprocal force is such that the crown will tend to move in the opposite direction to the apex, and the tooth crown must be ligated back to resist this unwanted movement. There is also a tendency for the tooth to extrude unless the mechanism is designed to prevent the tooth moving away from the archwire.

Whips (or rotation springs) are used to produce rotation of an individual tooth around its long axis (Figure 4.15(a)). The same principle can be used in the design of an accessory spring to upright a molar as in Figure 4.15(b). The availability of low-stiffness and high-range wires (nickel-titanium in particular) has to a large extent eliminated the need for whip springs when wide (edgewise) brackets are used.

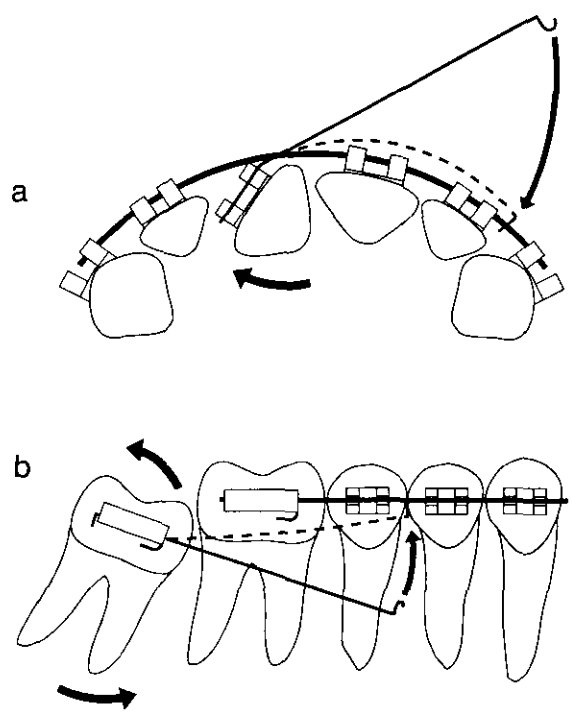

Figure 4.15 Accessory whip springs: (a) spring to rotate upper incisor; (b) spring to upright lower second molar

Magnets

The material available for the construction of magnets has improved in recent years. Among the new materials the alloy of neodymium-iron-boron has the highest magnetic energy per unit volume of any commercially available magnetic material. It is available at reasonable cost, and can be prepared in sizes appropriate for orthodontic use. Theoretically at least, it could be used either in repulsion or attraction to generate forces appropriate for tooth movement. A potential problem is that unlike the springs and elastics with which the orthodontist is familiar, magnetic force magnitude obeys the inverse square law, so that there is a difficulty in maintaining a constant force application, and a danger of applying excessive force.

Magnets are at present not very convenient to use. They are not readily available in a form which can be easily incorporated into fixed appliances. Nevertheless, there seems to be a place for magnets in fixed appliance work, perhaps particularly when dealing with severely displaced teeth.

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5

Case preparation

This chapter discusses the preparatory steps that must be taken prior to the commencement of fixed appliance treatment. Active orthodontic treatment lasts over an extended period of time and is generally followed by a period of retention. It is therefore necessary to develop a systematic approach to the management of the malocclusion.

It is advisable to have diagnostic records of the presenting malocclusion when formulating a diagnosis and treatment plan and in order to monitor treatment progress.

A detailed treatment plan, estimation of duration of active treatment and any retention period must be defined and recorded for future reference in the patient's notes. The treatment plan with an indication of the anticipated outcome should be discussed with the patient and parent (if the patient is a minor) before commencing treatment. The risks and benefits of orthodontic treatment should be discussed at this visit. Guidance is given in Appendix 1.

The demands and expectations of both patient and parent should be noted, together with appropriate comments on the anticipated co-operation and motivation on the part of the patient.

Diagnostic records

Orthodontic diagnostic records are a permanent reference of the presenting malocclusion and should be available at the chairside at each visit. These will usually include reference models, appropriate radiographs and clinical photographs.

Reference models

Impression trays designed for orthodontic use are preferable as they have extended flanges to ensure an accurate impression of the buccal and lingual sulci. It is certainly easier to identify changes in tooth position as a result of treatment, or spontaneous movement with the use of well extended models.

The position of maximum intercuspation should be recorded and the models trimmed appropriately. It is wise to check subsequently that the models record the patient's occlusion accurately. Preliminary measurements and prescription arch form templates will be constructed from the reference models (Chapter 6), and they should therefore be up to date.

Radiographs

Care must be taken in the prescription of radiographs. It is essential that the techniques used conform to modern safe practice. Particular attention should be given to the choice of radiograph, exposure time, developing, fixing and storage. The clinician has the responsibility of ensuring that the maximum information is obtained from the minimum number of exposures.

Radiographs should only be taken after a full history and clinical examination. There should be an identifiable potential advantage to the patient when submitting to a radiographic investigation. Although both positive and negative findings are important in formulating a diagnosis and treatment plan, the clinician should be aware of the dangers of ionizing

radiation, especially to young children. This must of course be balanced against the dangers of carrying out treatment without adequate radiographic information.

The dental panoramic tomograph (DPT), is widely used as a basic radiograph for orthodontic assessment. Although this radiograph gives an excellent view of both erupted and unerupted teeth in the buccal segments, it has limitations in the upper incisor region. The upper labial segment is an area where developmental anomalies often occur, pathology may be seen and where tooth movement is commonly carried out. For these reasons orthodontists consider it wise to supplement the DPT with an upper standard anterior occlusal radiograph.

If tomography is not available a rotated lateral oblique (bimolar), together with an upper and lower standard anterior occlusal is a satisfactory alternative.

A logical sequence of examining the radiographs will ensure all features are identified and highlight any areas where further investigation may be necessary. The following sequence is suggested:

- count the teeth – both erupted and unerupted
- examine the crowns of the teeth – both erupted and unerupted
- examine the roots of the teeth – both erupted and unerupted
- look at the supporting tissues and associated structures.

Additional radiographs may also be necessary if there is doubt over the prognosis of heavily restored teeth or if the periodontal history suggests that the alveolar bone support may have been compromised. With a greater number of adults seeking orthodontic treatment, often combined with periodontal and/or restorative procedures, adequate radiographs of the teeth, their roots and supporting structures must be available.

Teeth which have suffered mechanical trauma have the additional risk of loss of vitality and root shortening during active orthodontic tooth movement. Radiographic assessment of such teeth prior to carrying out tooth movement is a wise precaution.

Cephalometric radiographs are necessary if there is a clinical discrepancy in dental arch relationships in either the sagittal or vertical plane. Cephalometric radiographs enable an accurate assessment to be made of both the skeletal and dental factors which may be contributing to the malocclusion. As with all radiographs the maximum amount of information must be obtained from the films and it is necessary either to trace manually or digitize cephalometric radiographs.

The reproducibility and standard magnification of these radiographs enable them to be used to demonstrate changes that occur either as a result of growth, or orthodontic treatment. However it is important not to place too much emphasis on the planning of treatment from cephalometric radiographs alone.

Clinical photographs

Colour photographs should be taken whenever possible. They should form part of the pretreatment and diagnostic records and it is recommended that additional photographs should be taken at significant stages of treatment.

Extra-oral views should include full face, profile and three-quarter face. It is the three-quarter view of the face that is most commonly seen in social surroundings and is particularly useful to show facial maturation.

Intra-oral views should show all the teeth in occlusion. This is best achieved with an anterior view and right and left buccal segments. Mirror views of the upper and lower arches are particularly useful to demonstrate rotations and abnormal sequences of eruption. Clearly additional views may be necessary if there are teeth with abnormal morphology, decalcification or discoloration. These non-invasive records will form an important permanent record of the occlusion and dental condition at the commencement of treatment.

Management of the patient and parent

As orthodontic treatment takes many months to complete, a high degree of motivation and co-operation on the part of the patient and, in the case of a minor, parent are necessary. Not only must the patient's mouth be prepared but also the parents must understand that successful treatment can only be achieved with continuity of care and regular visits.

Preparation of the mouth

Oral hygiene

A high standard of oral hygiene must be demonstrated before commencing any form of orthodontic treatment particularly when fixed appliances are to be used. However, there are situations where, because of the malocclusion, a young patient may find it difficult to clean crowded teeth. Patients should be warned of the dangers and problems that may arise if fixed appliances are fitted and a high standard of oral hygiene is not sustained.

The patient should be advised in oral hygiene techniques, with the following guidelines:

- The teeth and appliances will need cleaning after every meal and before going to bed, using a toothbrush of the appropriate size. The use of an interdental brush may be advised.
- The use of disclosing tablets to identify areas not being correctly cleaned.
- The necessity to avoid snacks and sweetened acidic drinks.
- The daily use of a fluoride mouthrinse and brushing with a fluoride toothpaste.

It is wise to delay orthodontic treatment until a satisfactory standard of oral hygiene has been maintained for some months. To expect an improvement once appliances have been fitted is unrealistic. Patients who are unable to comply in spite of being given instruction should not be accepted for appliance therapy.

General dental health

Before fixed appliances are fitted a general dental examination should be carried out. Any teeth with carious lesions must be restored adequately before the appliances are placed. A note should be made of any crowns or large restorations which may lead to difficulties with the placement and removal of bands and bonds.

It can be helpful to record in the notes details of any root-treated teeth and those with morphological variations such as hypoplastic enamel, decalcification, cracks, fractures and stains. Teeth with a history of trauma will need to be tested for vitality regularly. After a period of fixed-appliance treatment patients and parents may forget about such details. As these imperfections become apparent at the completion of treatment questions may be asked as to their presence. Reference to the original notes and photographs may save discussion at the debonding stage regarding the presence and possible cause of these variations.

Many adults now present for orthodontic treatment which may require to be combined with periodontal and restorative procedures. Periodontal disease may be present with an associated loss of alveolar bone and supporting tissues. Control of the periodontal state is necessary before commencing orthodontic treatment and advice from specialists in other areas may need to be sought.

During orthodontic treatment there is often some shortening of the roots of teeth and increase in mobility. Any variation in root length must be identified at the commencement of treatment and both the patient and parent advised accordingly. It is wise to restrict orthodontic tooth movements to tipping of teeth using the lightest forces possible consistent with satisfactory tooth movement.

Treatment planning

Although orthodontic diagnosis is not within the scope of this book, it is important to stress the need for a full clinical assessment of the patient to be made before commencing treatment. It is often advantageous to reserve two appointments, the first, to obtain records, followed by a second appointment a week or so later to discuss treatment options. This gives time for the operator to consider the appliance mechanisms to be used and the patient to consider the implications of orthodontic therapy. It is advisable to have the reference models and radiographs available at the treatment planning appointment to demonstrate features to the patient and parent.

Before considering treatment certain questions should be addressed.

1. Is the patient's dental state and standard of oral hygiene satisfactory?
2. Has the operator identified the aetiological factors contributing to the malocclusion?
3. Can orthodontic treatment achieve a significant and stable improvement to the malocclusion?

The treatment plan should be formulated and written clearly in the notes with the following headings:

1. Aims of treatment.

2. Patient and parents' expectations from the proposed treatment.
3. The tooth movements required to achieve the aims of treatment.
4. The appliance mechanisms necessary to carry out the tooth movements.
5. Any extractions that may be indicated.
6. The retention that will be required.
7. The approximate time that treatment will take.

Case discussion

The aims and objectives of treatment and details of the treatment plan should be discussed with the patient, and where appropriate an accompanying parent or guardian.

The type of appliance to be used should be explained and clinical photographs of patients wearing such appliances, including headgear if appropriate, are a useful method of helping to ensure that the patient understands what their commitment will be to the treatment plan.

Some courses of orthodontic treatment require extraction of permanent teeth. Parents who have been conscientious in looking after their children's teeth may be resistant to the extraction of sound teeth. The reference models of the patient can be used to assist in explaining the reason for the loss of teeth.

The fitting and adjustment of a fixed appliance takes time, with attendance at regular intervals over a protracted period. Continuity of care is important and treatment should remain the responsibility of one operator whenever possible. The patient should ensure they will be available for regular visits over the period of time that treatment is likely to take.

Consent to treatment

In the past the need for informed consent for orthodontic treatment has been largely ignored. The fact that the treatment is carried out on a conscious patient, and that the patient voluntarily attends for the appointment, has led to the assumption that the patient agrees with the work undertaken. In the United Kingdom to date there has been little litigation associated with orthodontic treatment. Recently an increased public awareness of the possibilities of failure of medical or surgical treatment has resulted in a growing number of patients who, quite rightly, wish to question treatment and its possible sequelae. It is the responsibility of the practitioner to acquaint the patient or parent with the risks and benefits of orthodontic treatment before commencing therapy. It is also important to ensure that the patient understands what has been described to them. A signature on a consent form is not sufficient unless accompanied by a careful explanation to the patient.

The majority of orthodontic patients are below the age of legal consent which is 16 years in the United Kingdom. Therefore a parent or legal guardian is required to agree to treatment. It is a principle of law that if a minor is mature enough to appreciate the implications of treatment, then the patient must also give their consent to a clinical procedure. Practitioners should be aware that to fit a fixed appliance at a parent's request as a method of treating an unwilling patient is an infringement of the patient's rights. It is also unlikely to be successful clinically.

A check list provides a useful way of ensuring that the essential features have been covered. Clearly individual occlusions will have certain additional considerations which are not included in the following list which forms a general guide:

- duration of treatment;
- frequency of visits;
- discomfort from appliances;
- provision of a patient information leaflet;
- need for extractions;
- damage to teeth and gingivae if there is poor oral hygiene;
- prognosis of teeth at risk;
- the need for retention;
- the possibility of relapse;
- late lower incisor crowding.

Following presentation of the treatment plan to the patient and parent it is advisable to make an entry in the clinical notes recording the discussion and the consequences that have been described.

As orthodontic treatment is protracted and where fees require payment over a period of time, it is wise practice to write a letter to the patient or parent. The letter should outline the details of the treatment, the associated risks and the fee structure. The patient then has a clear under-

Table 5.1 Records required at commencement of treatment

1. Reference models
2. Radiographs
   DPT with anterior occlusal
   or
   bimolar and anterior occlusal
3. Photographic records
4. Aims and objectives of treatment
5. Treatment plan
6. Anticipated treatment time

standing of the treatment before appliances are placed. Practitioners may wish to have a copy of this letter signed by a responsible party before commencing treatment.

Commencement of treatment

When there is agreement to proceed with treatment it is advisable to ensure all the records required are available (Table 5.1). Arrangements should be made for the placement of the appliance and any necessary extractions. The fitting of the appliance is described in Chapter 7 and the scheduling of appointments and routine management in Chapter 16.

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6

Arch form

An important aim of orthodontic treatment is the stability of the end result. The factors determining stability of tooth position are complicated, and impossible to assess with accuracy. Furthermore, they are known to change throughout the patient's life, in a manner which is not entirely predictable. It is therefore not possible to identify precisely positions of stability either at the diagnostic stage or thereafter. Accepting these difficulties, certain types of tooth movement are known to be particularly liable to relapse. The orthodontist should either avoid such tooth movements, or be prepared to provide indefinite retention. There are a number of practical difficulties associated with the provision of indefinite retention and it should be avoided whenever possible. A degree of compromise is often required in terms of stability, and it is the duty of the orthodontist to explain this to the patient before treatment is started, and to involve the patient in the decisions to be taken when termination of the retention period is being considered.

The use of some arbitrary 'norm' of occlusion as a treatment aim in the hope of achieving a stable result is very likely to lead to disappointment.

On the other hand, it is unwise to begin treatment without a clearly defined and appropriate objective, or to use an appliance without carefully monitoring the changes in tooth position which it will produce. The risk is that of moving teeth into unstable positions, and 'relapse' which can be directly associated with uncontrolled orthodontic treatment.

What reliable guidelines are available? The detail of diagnostic considerations which should determine the positions into which teeth are moved is not within the scope of this book. There are, however, a number of important general principles which need to be borne in mind when using fixed appliances, and some of these are related to the arch form.

Arch form

The term 'arch form' refers to the overall configuration of the dental arch. The following basic characteristics can be identified (Figure 6.1):

- the radius of curvature of the labial segment;
- the intercanine width;
- the intermolar width.

The arch form which is seen before treatment commences provides valuable information about

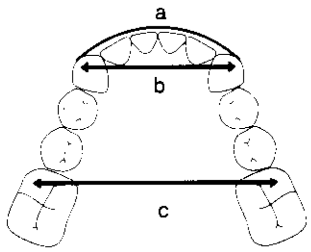

Figure 6.1 Basic characteristics of arch form: (a) curvature of the labial segment; (b) intercanine width; (c) intermolar width

the positions into which teeth can be moved if they are to be stable following treatment. There are situations in which alteration of the three basic characteristics of arch form are necessary, and can be expected to be stable (see below). It is, however, all too easy, when concentrating on the correction of local tooth displacements, to produce inadvertent changes. Such changes can be extremely difficult and time-consuming to correct, and if left uncorrected may lead to instability.

The radius of curvature of the lower labial segment

Alteration of the labio-lingual position of the crowns of the lower incisors is in general unlikely to be stable. A significant complication of appliance treatment in the lower arch is labial movement of the lower incisors into an unstable position (Chapter 2). This is particularly likely to occur as tooth displacements in other parts of the arch are being corrected – the lower incisors offer little resistance to proclination or retroclination. Unwanted labio-lingual movement of the lower incisor crowns is also produced by an incorrect radius of curvature in the labial section of the lower archwire. The pre-treatment 'average' labio-lingual position of the lower incisor crowns should be used as a guide (Figure 6.2).

The lower intercanine width

The positions occupied by the lower canines are important both mesiodistally and labio-lingually. In a mesiodistal direction the canines must be positioned so that there is just sufficient space to align the incisors. When the lower incisors are crowded the lower canines will need to be moved distally to provide space for incisor alignment. The canines may be crowded both mesially and labially before retraction – in this situation the lower intercanine width may need to be reduced as the canines are moved distally, but the radius of curvature of the lower labial segment and the degree of divergence of the buccal segments must be taken into account.

The general shape of the lower archwire changes from the curvature of the labial segment to the 'straight' buccal spans at the centre points of the canine brackets.

a

b

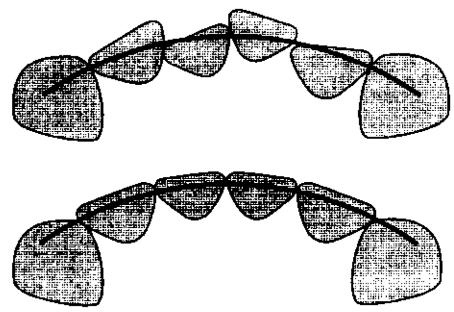

Figure 6.2 'Averaging' of the labio-lingual position of lower canine and incisor crowns: (a) before alignment; (b) after alignment, the canines have been moved distally and lingually, and the incisors aligned on the original curvature of the labial segment

The lower intermolar width

The pre-treatment intermolar width is another parameter which the orthodontist should treat with respect. If the molars are to be moved mesially or distally, then alteration in intermolar width is necessary, although attention must still be paid to the degree of pre-treatment divergence of the buccal spans. Alteration of lower intermolar width may also be required when a buccal segment crossbite is to be corrected.

Interrelationship of mandibular and maxillary arches

It is useful to plan the upper arch around the lower – using the lower arch as a template. The upper labial segment curvature, the upper intercanine width, and the upper intermolar width must relate to the positions of the corresponding teeth in the lower arch.

Arch symmetry

Perfect bilateral symmetry of arch form is uncommon. In some patients there is an obvious asymmetry which cannot be corrected permanently by orthodontic means. On the other hand, arches which are virtually symmetrical at the start of treatment can be made markedly asymmetric unless attention is paid to archwire form.

Arch form and fixed appliances

If unwanted alterations of arch form are to be avoided, the orthodontist must first be aware that change has occurred. It is important therefore to refer back to the three basic characteristics of arch form at each appointment.

Each successive archwire will influence the arch form. The **archwire form** – the shape of the archwire in terms of the three basic characteristics – is therefore a matter of great importance.

Early in treatment, when wires of lowest stiffness, for example multistrand wire, are in use for short periods of time, it is permissible to ignore considerations of archwire form. Later in treatment however, as progressively stiffer wires are used, careful attention to archwire form becomes increasingly important. A particular risk is the use of unmodified preformed archwires – which are likely to bear little resemblance to the shape of the arch which is required in terms of stability. The shape of preformed archwires will almost invariably need modification before they are put into use.

The aim is to achieve an arch form at the completion of treatment which has been **planned** at the commencement of treatment. As a means of encouraging attention to archwire form, the inexperienced operator is recommended to construct an Individualized Archwire Form for each patient.

Individualized Archwire Form

An Individualized Archwire Form is an invaluable aid, particularly to the relatively inexperienced operator. The method to be described provides a guide to archwire shape for the individual patient.

It is suggested that an Individualized Archwire Form be made for the patient before treatment is started. It can then be used as a guide for the construction of archwires throughout treatment, providing some safeguard against the movement of teeth into unstable positions. It must be emphasized, however, that the use of the Individualized Archwire Form does not obviate the need to monitor tooth position carefully visit by visit. Alteration of the archwire shape may well be required as treatment progresses (see below).

The pre-treatment lower reference model is used as a starting point when constructing the archwire template.

Constructing the archwire template

You will require the pre-treatment reference models, graph paper, dividers, compasses and ruler (refer to Figure 6.3).

1. *Labial curvature* To establish the curvature of the labial segment the widths of a lower central incisor, a lower lateral incisor and a lower canine are measured with dividers, and the total width of these three teeth is determined. To this measurement add 3 mm. The distance so obtained is the radius, OP, of a circle drawn on the graph paper. Draw the circle with the centre, P, on one of the main vertical lines on the graph paper. Mark point O, the centre point of the labial curvature where the vertical line intersects the circle.
2. *Canine points* The canine points, C and C, lie at the mid points of the canine crowns. Add together the widths of the central and lateral incisors on one side, and add half the width of a canine. Set the compasses to this distance, and with the point of the instrument on point O, mark C and C on each side.
3. *Intermolar width* Measure the distance across the arch between the mesiobuccal cusp tips of the lower first molars. Divide this distance in half. Draw a vertical line on each side parallel with, and at that distance from, the main vertical line on the graph paper.
4. *Canine to molar distance, CM* Measure the distance between the mid-point of the canine and the mid-point of the molar on the same side (if the sides differ, use the mean). Set the compasses to this distance. With the point of the instrument on one of the C points, mark M, where the arc intersects the vertical molar line. Repeat on the other side. Join C and M on each side and extend distally to complete the buccal spans.
5. *The upper arch template* This is constructed in a similar fashion, but using an initial circle with a radius 3 mm larger than that for the lower arch. It is convenient to construct the upper archwire form by overlaying it on the lower form – start by drawing the upper circle on the same centre point (P). The upper canine points are determined by adding the widths of an upper central incisor, an upper lateral incisor and half the width of an upper canine. The buccal spans are drawn parallel to those of the lower.

Molar, canine and incisor offset bends are incorporated in the archwires at the detailing and retention stages.

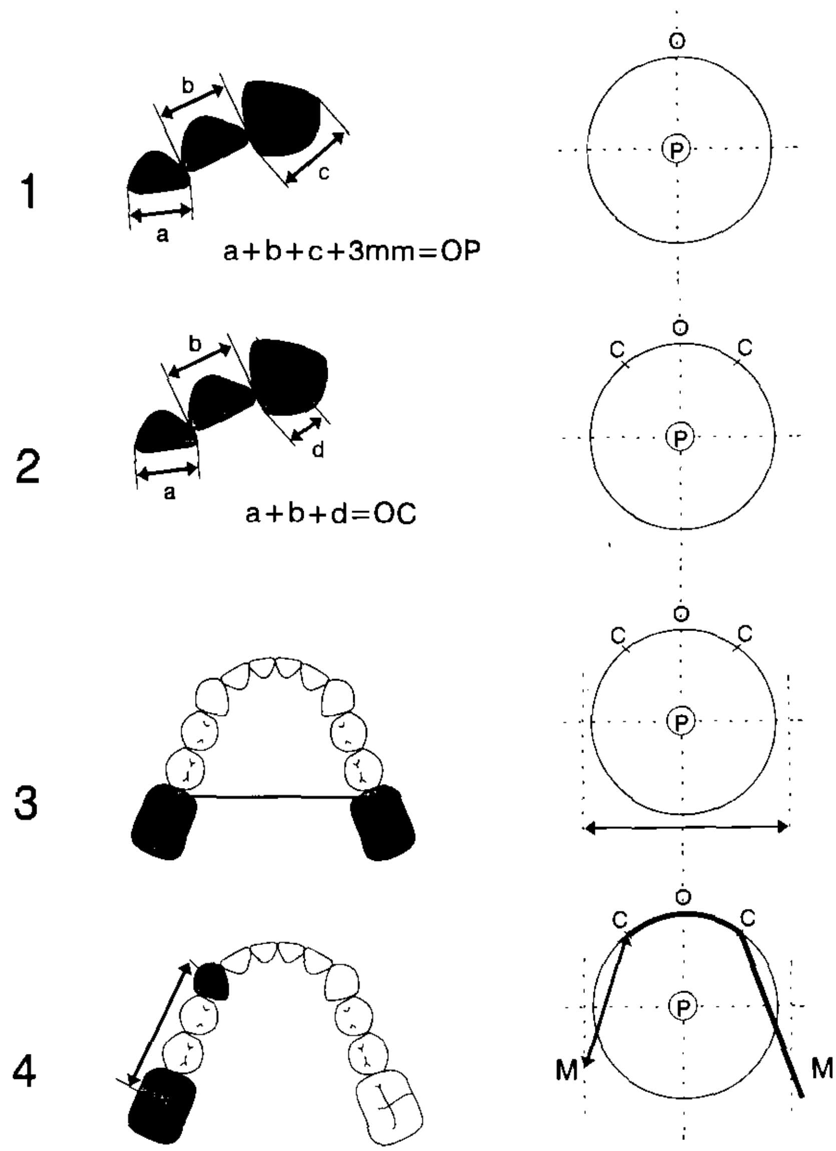

Figure 6.3 Construction of the archwire template (refer to text)

Using the Individualized Archwire Form

It is recommended that the archwire forms are used with all stainless steel single-strand archwires. Before the archwire is tied into the brackets its shape should be checked, paying particular attention to intercanine and intermolar width, and labial segment curvature. In addition, each archwire must be checked for flatness to avoid unwanted alteration of bracket level and symmetry, in order to avoid producing unwanted arch asymmetry.

Exact conformity of the archwire with the archwire form template will not guarantee against unwanted movement. The template can only provide a starting point. It must be remembered that in the early stages of treatment, marked local tooth displacements will have a significant effect upon the activation of the archwire – to such an extent that it is, in practice, impossible to predict with accuracy the detailed effect of the archwire. The true value of the archwire form lies in drawing the attention of the operator to possible changes in tooth

position, and assisting in the aim of achieving a planned and stable arch form at the completion of treatment.

Buccal crossbite correction

Expansion or contraction of the archwire intermolar width will produce movement of molars, although fairly rigid archwire (for example 0.020 in round stainless steel) will be necessary, and the correction will take a number of visits to achieve. For buccal movement the archwire should be expanded by approximately 2 cm overall.

Starting with an archwire form corresponding to the archwire template, it is important to consider the effect of altering the archwire intermolar width.

In Figure 6.4, the objective is to move both lower molars buccally. In Figure 6.4(a) the basic archwire form has been modified by increasing the buccal span divergence at the canine points so that the intercanine archwire width and labial curvature remain unaltered. When this archwire is tied in, it will move the molars buccally, but it will also reduce the intercanine width and increase the labial curvature. Considering the resistance of the molars, and the slow rate at which expansion is achieved, it will be important to monitor intercanine width and incisor position (Figure 6.4(b)). In order to prevent reduction of intercanine width it may be necessary to modify the archwire form as in Figure 6.4(c). In this case, the archwire expansion is achieved by 'flattening' the labial curvature rather than placing expansion distal to the canine points.

It may be necessary, rather than expanding bilaterally as above, to move only one side in a buccal direction. It is tempting, starting again with the symmetrical archwire form, to make the archwire asymmetric by expanding the buccal span on one side only. Unfortunately, an archwire of this shape will introduce unwanted asymmetry, and will still apply an equal buccally directed force to both molars. The correction of unilateral buccal crossbite requires a more elaborate mechanism – see Chapter 14.

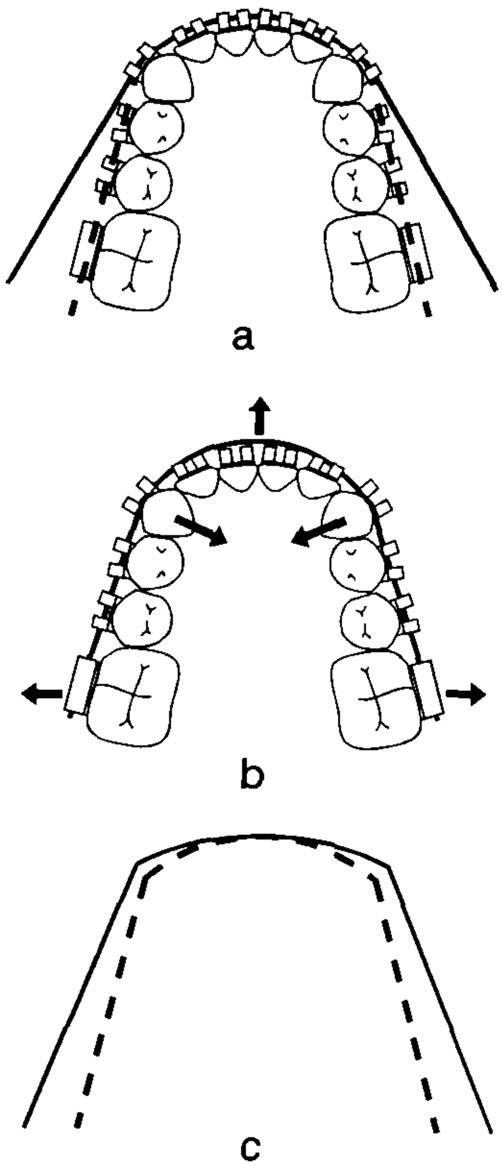

Figure 6.4 Effects of increasing intermolar width: (a) the archwire intermolar width has been increased by bends at the canine points; (b) shows the resulting molar expansion, canine contraction and incisor proclination; (c) shows an archwire in which the intermolar width is increased by flattening the labial curvature, so avoiding canine contraction and incisor proclination

Detailing of arch form

In the final stages of treatment small detailing bends are made in the horizontal plane of the upper archwire as shown in Figure 6.5. Canine eminence and molar offsets are also made in the lower archwire. These detailing bends will ideally not be necessary when preadjusted brackets are in use.

Preformed archwires

Preformed archwires are available in a variety of wire materials and shapes. They have the

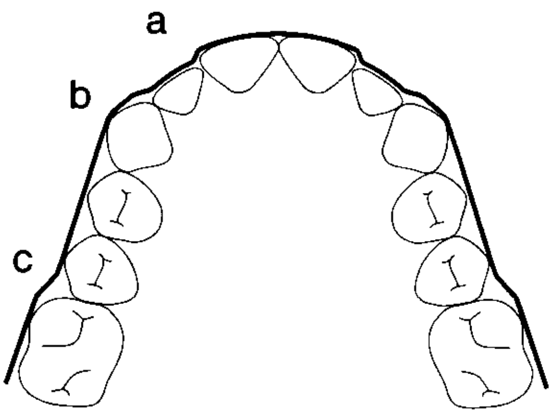

Figure 6.5 Detailing of upper arch form: (a) lateral incisor insets; (b) canine eminence; (c) molar offset

advantage of ease of use, and are particularly attractive for use with 'straight wire' appliances. The disadvantage of using preformed archwires is that of producing an arch form at the end of treatment which corresponds only with the manufacturer's concept of 'ideal' arch form. This becomes a matter of increasing importance as treatment progresses. At the stage of initial alignment preformed archwires of low stiffness (for example nickel-titanium and multistrand archwires) are safe to use because they will have insignificant effect on arch form. In the mid-treatment and detailing stages however, it is necessary to adjust the shape of preformed archwires to take into account individual requirements of arch form.

Further reading

Andrés De La Cruz, R., *et al.* (1995). Long-term changes in arch form orthodontic treatment and retention. *American Journal of Orthodontics* and *Dentofacial Orthopedics*, **107**, 518–30.

Felton, J. M, Sinclair, P. M., Jones, D. L. and Alexander, R. G. (1987). A computerised analysis of shape and stability of mandibular arch form. *American Journal of Orthodontics*, **92**, 478–83.

Little, R. M (1990). Stability and relapse of dental arch alignment. *British Journal of Orthodontics*, **17**, 235–41.

7

Fitting the appliance

It is important to allow adequate time for the fitting of fixed orthodontic appliances. Careful attention to detail and precise positioning of the appliance is required in order to avoid introducing errors that may lengthen the treatment period and make a satisfactory result more difficult to achieve.

The appliance may be fitted in either one or two visits, depending on preference, and the need for tooth separation. At the fitting appointment(s) time will need to be set aside for the following procedures:

- bracket or band placement;
- inserting the archwire;
- instructions to the patient.

Bracket placement

Orthodontic brackets are the attachments through which forces are applied to the teeth. They allow the placement of archwires and other auxiliaries to bring about the desired tooth movements. The precise relationship between the brackets and the teeth is of great importance and this will be covered in detail later in this chapter. The method of attaching the bracket to the tooth is either by 'direct bonding' or by using a stainless steel band.

Direct bonding

The development of enamel acid etching allows orthodontic attachments to be fitted directly to the tooth surface. The technique of direct bonding is now commonplace in orthodontics and has all but eliminated the use of bands on anterior teeth. However, there are both advantages and disadvantages, and these will be discussed later.

Successful bonding depends upon three factors:

1. The bracket base

Orthodontic brackets are manufactured with specially prepared bases (Plate 8) which provide a mechanical means for the adhesive to gain attachment to the bracket. In the case of metal brackets the adhesive gains its attachment through a mechanical bond, although when glass ionomer cement is used there is some chemical bonding of the adhesive to the metal. Plastic brackets bond chemically to the adhesive resin. Some ceramic brackets are manufactured with a chemical bonding agent on their base, but most depend upon a mechanical bond with the adhesive.

There are various types of bracket base. However, all provide a mechanically retentive base for the adhesive to flow into and so provide a mechanical bond to the adhesive. Brackets, molar tubes, and lingual attachments can all be bonded in a similar way.

It is important that the bracket base is kept free from any contamination – the bracket is best handled using tweezers. Touching the bracket bases with fingers or rubber gloves should be avoided.

2. *The adhesive*

A number of adhesive materials are available, and by far the most commonly used for orthodontic purposes are the composite resins. The vast majority of these are chemically activated, the setting reaction being initiated as the two components of the adhesive are brought into contact. A technique commonly employed in orthodontics is the 'no-mix' system which utilizes a two-component system consisting of a liquid and a paste. Following the etching of the tooth, a film of the liquid is applied to both the tooth surface and to the bracket base. The adhesive paste is applied to the bracket base, which is then positioned on the tooth surface. Small gyratory movements of the bracket on the tooth produce sufficient adhesive mixing for the setting action to be initiated. Specially designed bracket placement tweezers are particularly helpful when using this technique.

The term 'no-mix' is misleading because mixing does take place, albeit on the tooth surface. It is important that the bracket is pressed firmly against the tooth surface during this process to reduce the thickness of adhesive to a minimum. To fit the labial surface of the tooth to be bonded, bracket bases are manufactured with contoured bases: flat bases for incisors and curved bases for canines and premolars. Some of the more sophisticated bracket systems are manufactured with 'compound contoured bases' which provide an individual fit for each tooth in the mouth.

A disadvantage of the no-mix technique is the limited working time of approximately 30 seconds. As an alternative, light-activated composite resin systems offer the operator a fully controllable working time with 'command-setting' once the correct bracket position has been achieved. Light-activated systems have the disadvantage of being more lengthy procedures overall.

Another alternative is the use of a technique known as 'indirect bonding'. Here the brackets are positioned in the laboratory onto a study model and are then supplied to the operator having been fixed to a tray or jig. The brackets are located in place using the jig, which is later removed. The light-cured composites lend themselves well to this technique, which has the advantage of offering the potential for a more accurate placement of the brackets. The drawbacks are that moisture control may be more difficult with this technique; it requires an extra patient visit for the impression; and the laboratory work involved will increase costs. The technique may find its greatest use where bracket placement is particularly difficult such as in 'lingual orthodontics' where specially designed brackets are bonded to the lingual surfaces of the teeth.

In an attempt to reduce the likelihood of decalcification occurring adjacent to the attachments, fluoride releasing glass ionomer cement is used as an alternative to composite resins by some operators. This has the advantage of eliminating the need for etching of the tooth surface but its poorer bond strength does lead to a greater number of bond failures during treatment. However, the principle of fluoride release is important and fluoride releasing orthodontic composite resins are becoming available.

3. *The tooth surface*

In order to provide the adhesive with a good surface for bonding, the tooth should first be cleaned, using a prophylactic polishing paste. Recent studies have shown no reduction in bonding strength if the paste is either oil-based or contains fluoride.

Adequate drying and access to the teeth to be bonded is important and to this end cheek retractors, cotton wool rolls, dry guards and saliva ejectors are useful. Access becomes increasingly difficult the further back in the mouth the operator tries to bond and this is a factor involved in the greater incidence of failure of molar and premolar bonds. In addition, there is some evidence to show that some premolars may have a different enamel morphology, leading to reduced bond strength. In these situations, banding may prove a better alternative.

After washing of the cleaned teeth, pretreatment of the tooth surface using phosphoric acid is required to etch the enamel to a depth of some 25 microns. The etchant may be supplied as a liquid or as a gel according to personal preference. An etching time of 30 seconds is the recommendation for adolescent teeth, although adult teeth may need a longer etching time. After etching, the acid must be washed from the tooth surface and the prepared area rendered dry. In order to maintain the etched surface free from contamination after washing, many operators choose to dry the tooth using a moisture- and oil-free air system such as an independent warm air supply.

Brackets for bonding should be carefully identified prior to placement to ensure that the right bracket is placed on the tooth and in the correct orientation. This is essential when using a preadjusted system as there is usually a different bracket for each tooth. When placing the bracket it should be viewed from both the buccal and incisal aspects of the tooth using a mouth mirror to check for horizontal and rotational errors. Once the position is correct the bracket should remain untouched until the adhesive has set; disturbance during setting will increase the likelihood of bond failure.

Bracket position

The location of the bracket on the crown of each tooth is a matter of considerable importance. The aim is to place the brackets so that when the final archwire is in place at the completion of active treatment the crowns of all the teeth are correctly positioned.

Ideal positioning of brackets is a difficult procedure, particularly when there is considerable tooth irregularity. If a bracket is incorrectly placed it will require repositioning at a later stage of treatment. If the misplaced brackets are not rebonded discrepancies in tooth position will have to be accepted, or the archwires will require tedious adjustment throughout treatment.

Experience with bracket placement will allow the operator to position the brackets by eye, but for the newcomer to fixed appliance technique it may be helpful to draw pencil marks on a reference model of the patient, as a guide to bracket position (do not mark the teeth themselves as permanent marking may occur). Alternatively one of a number of measurement gauges may be used. Some brackets are supplied with colour coded placement jigs to assist their siting on the tooth.

The following variables need to be considered when positioning a bracket:

1. Mesiodistal location

The mid point of the bracket base should be placed equidistant from the mesial and distal surfaces of the crown. The use of a mouth mirror is normally required to ensure that the bracket has been positioned accurately. Crowding or rotation of a tooth may prevent correct mesiodistal placement of a bracket, in which case a note should be made in the records to reposition the bracket when the displacement is corrected.

2. Vertical height on the crown

The vertical positioning of the incisor brackets needs to anticipate the means whereby all the incisal edges can eventually be brought to their correct level and the best appearance achieved. The most obvious reference point to use when deciding the vertical height of the bracket channel is the incisal edge for incisors, and the cusp tip for other teeth.

When using standard edgewise brackets a distance of 4 mm between the incisal edge on the central incisors and the mid point of the archwire channel is generally appropriate. For the upper lateral incisors use a distance of half a millimetre less - 3.5 mm. For the remaining teeth, a 4 mm distance between incisal edge or cusp tip and archwire channel is used.

The principle is to maintain a consistency in bracket height for each arch so that inadvertent vertical irregularities in crown position are avoided. Comparison of bracket heights with adjacent and contra-lateral teeth should be made throughout the bracket placement process.

When the incisal edge of an incisor is fractured or has undergone attrition the operator must decide at the bracket positioning stage how the deficiency at the incisal edge is to be corrected at the completion of treatment and bond the bracket appropriately.

When a tooth is only partially erupted it is not possible to place the bracket in the ideal position. The bracket will then require to be repositioned at a later stage of treatment.

When using straight wire brackets the vertical height of the bracket channel is important if the programmed characteristics of the bracket are to be properly expressed. Straight wire brackets incorporating torque 'in the base' depend particularly upon precise vertical positioning, and they need to be placed with the mid point of the bracket base on the vertical and horizontal mid point of the crown.

Begg brackets are less sensitive to precise positioning, but the 'tip-edge' variant, as with edgewise systems, requires precise bracket location.

3. Angulation of the bracket

The angulation of the bracket in relation to the crown of the tooth will determine the angulation of the tooth, and influence the position of the root apex. Once again, correct positioning is vital, particularly when wide (edgewise) brackets are in use. From the point of view of aesthetics the angulation of the crowns of the teeth in the upper incisor region at the end of treatment must be correct to achieve the best results. Bracket placement is therefore considered in relation to the crown rather than to the long axis of the tooth.

When standard edgewise brackets are in use, the obvious reference line is the incisal edge and the bracket is placed so that the archwire channel is parallel to the incisal edge (Figure 7.1.). In the case of canine, premolar and molar teeth the bracket angulation is set so that the archwire channel is at right angles to the vertical axis of the crown.

Attrition or fracture of an incisor can make difficulties in correct bracket angulation. As before, the operator must anticipate the final morphology of the incisor crown when placing the bracket.

Straight wire brackets again require a different approach as compared to standard edgewise brackets, because they have programmed archwire channel angulation for each tooth. Unlike standard edgewise brackets where the archwire channel is parallel to the edges of the bracket, with a preadjusted system the bracket slots will be angulated and will no longer be in line with the bracket base. With a preadjusted system it is often useful to position the bracket by reference to the vertical axis of the bracket wings and make these parallel to the long axis of the crown. However, the particular manufacture and design of the bracket will determine the precise method of placing the bracket at the correct angulation.

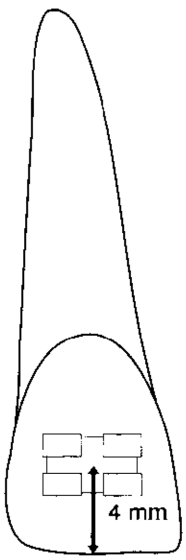

Figure 7.1 The suggested position for a standard edgewise bracket on an upper-right central incisor

Occasionally a situation may arise where a tooth has a considerable root dilaceration – such that if the crown is moved into an ideal angulation there is a risk that the root will be brought into contact with neighbouring roots. It will be necessary in this situation to monitor root movement carefully, and to stop tooth uprighting before there is a danger of initiating root resorption.

4. Labio-lingual positioning

It is essential with all bonded brackets to ensure that the bracket is pressed firmly into contact with the tooth surface at the time of bonding. If this advice is not followed the archwire channel will be displaced away from the tooth surface so that 'in-out' discrepancies in tooth position will arise. The brackets must be placed correctly on the surface of the tooth if the 'in-out' characteristics of straight wire brackets are to be properly expressed.

The main issue is that at the end of treatment all the **bracket channels** will be aligned. If they are incorrectly located then the teeth will be misplaced unless compensating bends are made. However, when using preadjusted brackets, such as the 'straight wire appliance' it is critical that the brackets are correctly positioned. The introduction of compensating bends increases the time taken for bending and fitting archwires and inhibits the use of sliding mechanics whereby teeth move along the archwire at a predetermined angulation and inclination (Chapter 13).

Failure to place the brackets in the correct position will produce a number of unwanted errors in tooth position. These will be discussed in turn:

Mesiodistal errors Occasionally a bracket may be positioned intentionally more towards either the mesial or distal aspect of a tooth to aid the

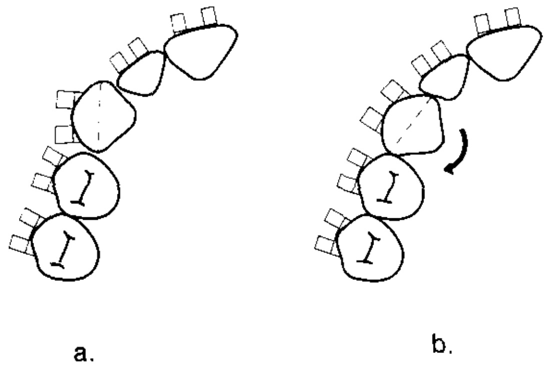

Figure 7.2 Bracket offset on a rotated canine (a) has produced overcorrection of the rotation at the end of treatment (b)

correction of a rotation, or even to over-correct the tooth's position (Figure 7.2). However, unintentional bracket positioning errors in the mesiodistal direction will produce a rotational error in the position of the tooth, the effect of which will be increased if the tooth has a convex buccal surface such as a premolar or a canine. Mesiodistal errors are best seen from the incisal edge or the occlusal surface.

Vertical errors Errors in bracket position in the vertical plane will produce crowns of differing heights in relation to the occlusal plane when bracket levelling is complete. Again, this may be intentional if it is necessary to extrude or intrude an individual tooth. More commonly the errors are not deliberate and either the brackets will need to be repositioned or a compensating bend placed in every archwire used.

'In-out' errors These are often produced as a result of an excessive layer of adhesive underneath the bracket base. The bracket should be pressed firmly against the tooth surface when bonding to ensure the thinnest layer of the adhesive. Errors in this plane are often not noticed until late in treatment at which stage they may be best treated by placing a compensating bend in the archwire called a 'first-order' bend.

Angulation errors The principle here is that with standard brackets 'second-order' archwire bends will be needed if any crown tip is required. When preadjusted brackets are used and correctly positioned, the 'correct' angulation of the channel is achieved automatically.

Errors in bracket angulation will produce undesirable angulation of the teeth with respect to the occlusal plane. This may be introduced intentionally where the bracket has an incorrect amount of tip built into it for that tooth, such as a standard edgewise bracket for an upper canine tooth. However, rotating a standard concave based bracket on a convex tooth will prevent the bracket from fitting firmly against the tooth's surface and may introduce 'in-out' errors.

It it is important to pay attention to detail at the appliance fitting stage to reduce the introduction of unwanted tooth movements. Bracket positioning errors should be corrected by repositioning of the bracket at the earliest opportunity.

Molar tube position

Molar tubes are usually welded to molar bands but may be directly bonded to the teeth as described above. The tubes should be positioned parallel with the occlusal surface of the molar and, with a prewelded band, this should occur automatically if the band is correctly positioned on the tooth (Figure 7.3).

Indications for banding

Although the direct bonding of brackets is common, there are a number of situations where the use of bands is advantageous.

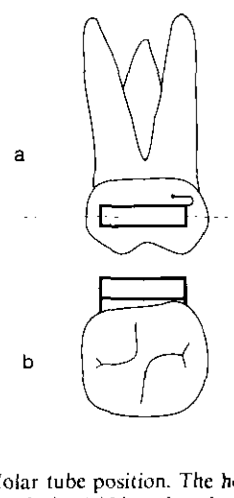

Figure 7.3 Molar tube position. The headgear tube has been omitted for clarity. (a) Note the tube is parallel to the occlusal surface of the tooth; (b) this is a preadjusted molar tube with a large distal offset

1. It has been shown that on anterior teeth, directly bonded brackets have a lower rate of failure than bands. However, on posterior teeth bands are more reliable than bonds, probably because of the difficulty of moisture control posteriorly during the bonding process, and due to the ability of bands to resist occlusal forces better than directly bonded brackets. Some operators prefer to band premolars. The occlusal edge of the band assists in visualizing the bracket position in relation to the occlusal plane.
2. It is unwise to bond molar attachments when extra-oral forces are to be applied to molar tubes. A band is more likely to resist displacement by the heavy forces employed. If the molar tube is bonded to the tooth, failure of the bond while the headgear is being worn may cause the patient injury.
3. Banding is particularly useful if a tooth requires not only a buccal but also a lingual attachment. A band carrying two suitable attachments will be quicker and easier to fit than two separate bonded attachments.
4. Although it is possible to use special adhesive systems to bond brackets to porcelain restorations, many operators prefer to cement a band on such teeth. Large amalgam or gold restorations may also necessitate the use of preformed bands. Likewise, a bracket which repeatedly fails to remain adhered to the tooth should be replaced with a band.

Banding

Stainless steel, seamless bands should be used. These can be stretched over teeth to make them self-retentive. They should not extend onto the occlusal surface nor occlude with teeth in the opposing arch. In addition to the position of the band, the precise relationship between the tooth and the bracket or tube remains of great importance. The essential principles concerning the correct bracket height and angulation are the same, whether one is banding or bonding.

Separation

In many cases the fitting of bands is difficult because of the interdental contact points. Where these contacts are very tight, it is unwise to force the band through the interdental contact point as it may become distorted in the process. This can also be uncomfortable for the patient. In addition, such a tight tooth contact in the interproximal area may give the false impression of a well-fitting band. It is therefore advisable to separate the teeth prior to banding.

Separation is frequently required on premolar and molar teeth. Tooth separation may be achieved using elastomeric rings placed around the contact points (Plate 9) using two pairs of mosquito forceps, dental floss or a pair of specific separator pliers. Some contact points, such as those associated with impacted teeth or teeth with large interproximal restorations, prove to be inaccessible for the placing of a separator from the occlusal surface and it may be necessary to resort to threading soft 0.5 or 0.6 mm brass wire around the contact point. The two ends are then twisted tightly together, the excess removed and the ends tucked between the teeth to avoid soft tissue irritation. Other methods of separation, such as separating springs, are available but all work on the same principle of applying pressure to the teeth at the contact point area.

Separators should be left in place for about seven days, during which time some discomfort may be experienced by the patient. On removal of the separators sufficient space should be available to proceed with banding.

Band selection

Preformed bands complete with welded brackets and attachments are available commercially in a wide range of sizes. Only rarely is it necessary to construct a band from stainless steel tape.

Initially the reference models may be used as a rough guide until band selection becomes easier with experience. Bands tried in the mouth but discarded should be sterilized and reshaped before being returned to the band box. It is worth while noting the final band sizes in the patient's notes for future reference in case a band is later lost or damaged beyond repair.

Bands are positioned using band seating instruments applied to their occlusal edges. While certain bands have seating lugs attached to their palatal or lingual aspects, it is advisable not to apply pressure to the attached brackets or molar tubes as this may result in a distortion of the bracket or slot with consequent problems later with archwire placement. Care should also be taken at this stage to avoid band seating instruments slipping from the tooth and causing trauma to the soft tissues.

The desired position of a preformed band will depend upon the optimal bracket position, described earlier. However, the ideal position for a molar or premolar band is for the edge to rest just under the gingival margin without causing any blanching of the gingiva. This may necessitate reducing the gingival aspect of the band with a stone. In adults, where the clinical crown will be longer than it is in children, it is sometimes not possible to seat the band below the gingival margin. Care must then be taken to see that the gap is not a small one, which may lead to stagnation, plaque accumulation and possible decalcification. The band should not extend onto the occlusal surface of the tooth, or the band will soon become loosened by occlusal forces.

Band cementation

The careful cementation of bands is vital to ensure successful results with fixed appliances and to minimize the risk of tooth decalcification. The number of bands which can be cemented satisfactorily with one mix of cement is limited, although the cooling of the cement mixing slab may increase the working time. When cementing a number of bands on adjacent teeth it is best to seat the bands progressively and not to seat the first band fully until the second band is at least partially seated.

Prior to cementation, the teeth which are to be banded must be thoroughly cleaned with prophylactic paste to remove plaque, and subsequently kept dry during cementation. If cotton wool rolls are used for isolation, great care must be taken not to let the rolls become trapped under the gingival edge of the band. It is essential that there is sufficient cement on the bands to fill the space completely between the band and the tooth. Some operators attach tape to the occlusal surface of the bands which allows the inner surface to be filled with cement. In addition it is important to keep the attached brackets and tubes free from the cement. Some brackets are available fitted with preformed bracket protectors. Alternatively covering the brackets with soft wax prior to cementation may help, although care must be taken to avoid any contamination of the band's fitting surface with the wax.

Excess cement may be wiped off the tooth using a dry cotton wool roll before it is fully set. Alternatively, any excess cement can be removed when it is set using a hand instrument.

The introduction of glass ionomer cements has generally superceded the use of zinc phosphate cements. The main advantage of these cements is their ability to act as reservoir for fluoride ions which are released throughout the treatment period, so reducing the possibility of decalcification. In addition, these cements can chemically adhere to enamel and stainless steel and are less liable to dissolution in the mouth than many other cements. When a band does fail it often leaves a layer of cement on the tooth so protecting it from the oral environment.

Archwire placement

When banding and bonding is complete an archwire is selected, adjusted as necessary and fastened to the brackets. With a few exceptions the archwire will be secured to the brackets using either stainless steel ligatures or elastomeric rings (bracket elastics). The selection and use of various bracket ties will be discussed later when considering the initial bracket levelling and alignment (Chapter 10).

Before the patient has completed this appointment it is important that adequate instructions are given regarding the care of the appliance. This is fully covered later (Chapter 16).

Further reading

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8

Intra-oral anchorage

Much of the success of orthodontic treatment depends upon careful anchorage management. The principles of anchorage have been discussed in Chapter 2. This chapter will discuss clinical methods of intra-oral anchorage management. To ensure anchorage control, the operator must be able to influence the resistance to movement offered by a tooth or group of teeth. The essence of practical anchorage management is the control of forces on teeth in order to achieve the treatment aims.

In practical terms the orthodontist must decide where the resistance to the forces required to carry out the desired tooth movement is to come from. This is termed **anchorage planning**. During orthodontic treatment movement must be anticipated not only in the teeth intended to be moved but also in the teeth providing anchorage.

The resistance to forces may be provided:

- by teeth in the same arch – intramaxillary anchorage;
- by teeth in the opposing arch – intermaxillary anchorage;
- by soft tissues – lips, cheeks and palate;
- from outside the mouth – extra-oral anchorage (Chapter 9).

Anchorage management: practical considerations

When planning anchorage a number of questions must be addressed:

- Which teeth are to be moved?
- What type of tooth movement is required – tipping, uprighting or torqueing?
- Where should the teeth be moved to?
- Is there sufficient space to move them into?
- Will there be excess space to close?

Effective anchorage management demands an understanding of the principle that when a force is applied in one direction, an equal and opposite force is applied to the structures providing the anchorage. It must be remembered that when anchorage is located intra-orally there may be some movement of all teeth to which a force is being applied.

It is essential to identify the anchorage requirements before the commencement of treatment, particularly as the choice of extraction may determine the anchorage considerations. In some instances it is necessary to prevent any movement of teeth providing the anchorage. In other cases a variable amount of movement of the teeth providing the anchorage is permissible or indeed desirable. This is referred to as **anchorage loss**.

Extractions should be planned according to the amount of space required and the type of tooth movement that is necessary. Tipping of teeth towards an extraction site is not very demanding upon the available anchorage. On the other hand bodily movement requires considerably more anchorage. In practical terms the amount of anchorage available is related to the space into which the anchorage unit can be allowed to move. Anchorage problems can occur when there is insufficient space for the anchorage unit to move into and also when there is excessive space which requires closure.

Intramaxillary anchorage

When forces are applied between teeth in a single arch the term intramaxillary traction is used. Either individual teeth or a group of teeth can be used to provide anchorage from which a force can be delivered to other teeth.

The principles of intra-oral anchorage management will be considered, using as an example, a crowded lower arch. The factors determining the amount of movement in response to an applied force are as follows

Root surface area of the anchorage unit

Consider the retraction of a lower canine (Figure 8.1). It is assumed that the initial stages of levelling and aligning have taken place. The tooth is to slide distally along a rigid archwire. The combined root surface area of the first molar and second premolar is far greater than that of the canine, and the balance is in favour of the canine moving more than the anchorage unit. There will be some mesial movement of the anchor teeth. If forward movement of the anchorage unit is to be restricted it would be an advantage to band the second molar and incorporate it into the posterior anchorage unit by tying it to the first molar or alternatively applying the traction force to the hook on the second molar (Figure 8.2). By this means the root surface area of the anchorage unit is increased.

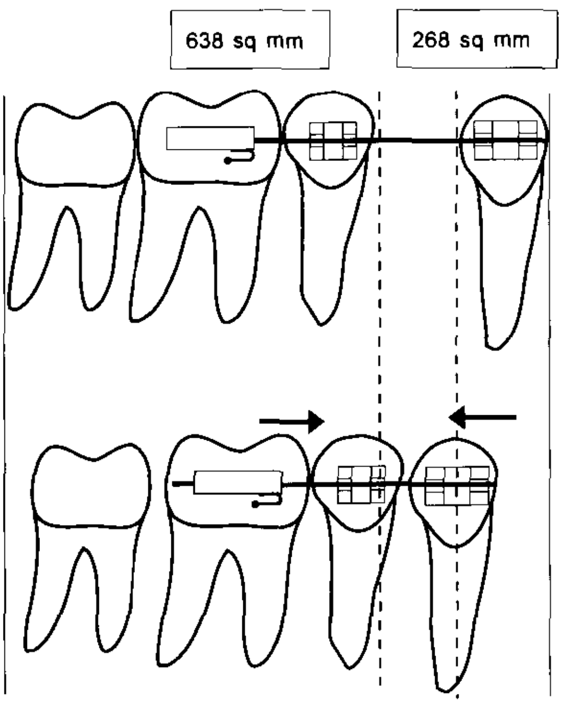

Figure 8.1 Canine retraction against a posterior anchorage unit

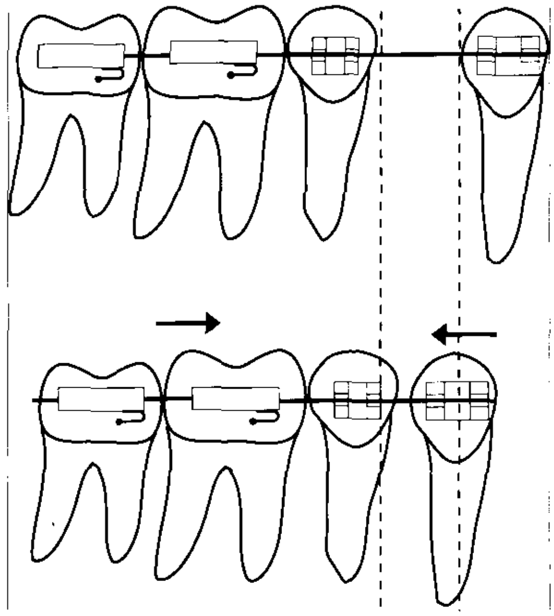

Figure 8.2 Incorporating the second molar will increase the anchorage value of the buccal segments providing traction is applied to the second molar hook. Alternatively the second molar is ligated to the first molar and second premolar

Extraction choice and anchorage balance

If the second premolar had been extracted instead of the first premolar the anchorage balance will have changed. Both the first premolar and the canine will need to be retracted and this will place greater demands upon the anchorage.

There are now two options to consider: retracting the first premolar and canine together, or retracting them separately. Two factors need to be considered. Firstly the size of the teeth to be retracted against the anchorage unit and secondly the time taken to retract the teeth.

Retracting the canine and premolar together will require a greater force applied from the anchorage unit than when retracting the teeth individually. The root surface area of two teeth and the frictional component of two brackets will be greater than that of one tooth (Figure 8.3). The alternative of retracting the teeth

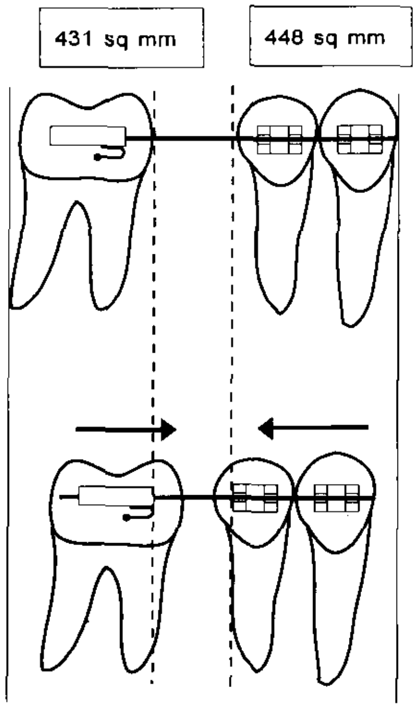

Figure 8.3 Retracting a premolar and canine together will result in significant forward movement of posterior segments

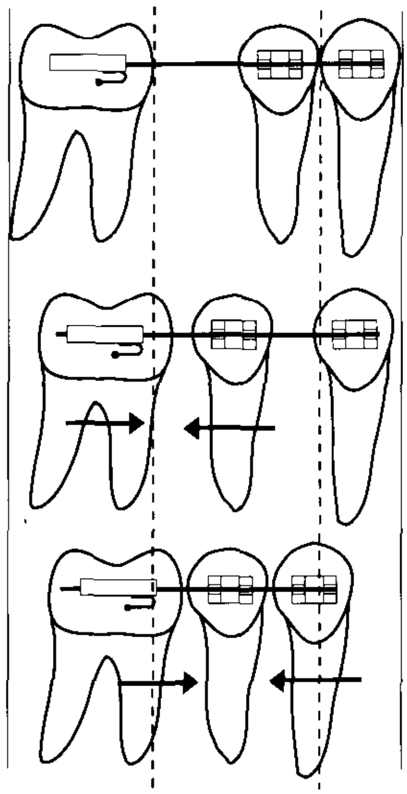

Figure 8.4 Separate retraction of first premolar and canine

individually will take longer. In practice it is advisable to retract the teeth individually using the lightest possible force (Figure 8.4).

Control of tipping

If there is only just sufficient space following the extraction of the first premolar for the alignment of the canine and incisors, forward movement of the molar teeth must be prevented. There is a natural tendency for posterior teeth to tip mesially towards an extraction space. Anchorage bends can be used to restrict mesial tipping (Figure 8.5).

A 30° anchorage bend will tend to tip the molar distally and offset the tendency for the molar to move forwards by mesial tipping. The anchorage bend, therefore, increases the anchorage value of the molar. The principle of allowing some teeth to tip freely, while restricting tipping of other (anchor) teeth is one often used in orthodontic anchorage management.

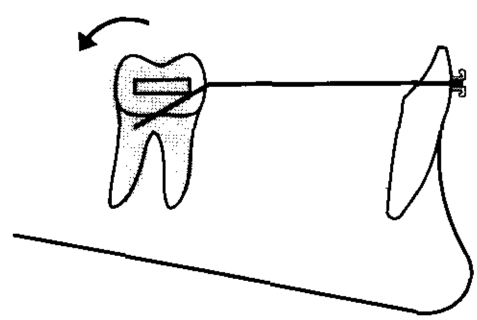

Figure 8.5 An anchorage bend will tend to tip the molar distally. (The effect on the incisors is not shown in this diagram)

Utilizing torque control

The anchorage value of the labial segments can be enhanced by the application of torqueing forces which make the teeth more resistant to palatal or lingual tipping. This can be achieved by applying a torqueing force to the incisors using close fitting rectangular wire in an edgewise bracket slot (Figure 8.6). As an example labial crown torque will tend to tip the incisors forwards which may be utilized to offset the lingual force of space closing mechanisms. It should be noted however that the lower incisors offer little anchorage value compared to molar and canine teeth even when prevented from tipping.

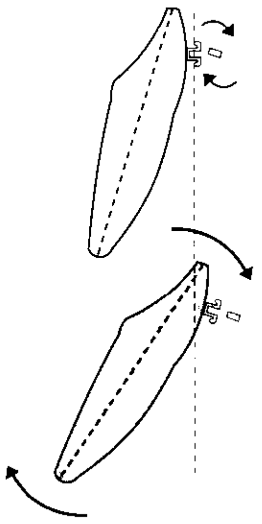

Figure 8.6 Labial crown torque tends to move the incisor crowns labially, and apices lingually

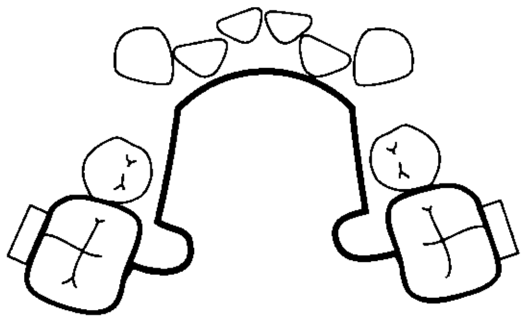

Figure 8.7 Soldered lower lingual arch

Palatal and lingual arches

Single-arch anchorage reinforcement may be achieved intra-orally with the use of rigid palatal or lingual arches attached to molar bands (Figure 8.7). The uses of palatal and lingual arches are described later in this chapter.

Intermaxillary anchorage

The resistance to movement will be increased by including as many teeth as possible into an anchorage unit. There is a limit to the number of teeth available within a single arch but it is possible to utilize teeth in the opposing arch. In this way a group of teeth in the mandible can provide anchorage for tooth movements to take place in the maxilla or vice versa. Force transmitted from the teeth in one arch to teeth in the opposing arch is termed 'intermaxillary traction'. The direction of these forces can be varied depending upon the clinical requirements.

Class II traction

This is so called because it is often used to correct a Class II malocclusion. Traction from the distal aspect of the lower arch is directed to the anterior aspect of the upper arch, usually to reinforce anchorage where an overjet is being corrected (Figure 8.8). It is generally best to use class II traction when there is space available mesial to the lower first molars. However, a force level which is ideal to retract upper incisors, when applied to a well-aligned, fully bracketed lower arch with a rigid archwire may only cause minimal reciprocal tooth movement.

An example has been given of a lower arch being used to provide anchorage for overjet reduction. In a similar manner a fully bonded upper arch could provide anchorage for mesial movement of lower molars with buccal segment space closure. Both of the above examples are termed class II intermaxillary traction (Figure 8.9).

Class III traction

Traction applied from the distal aspect of the upper arch to the anterior of the lower arch is termed class III traction. The upper arch is then

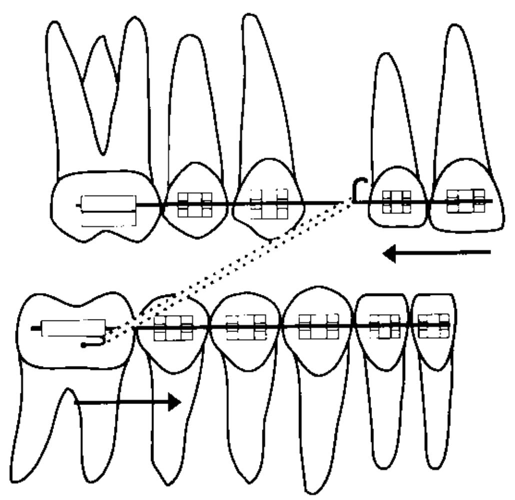

Figure 8.8 Class II intermaxillary traction

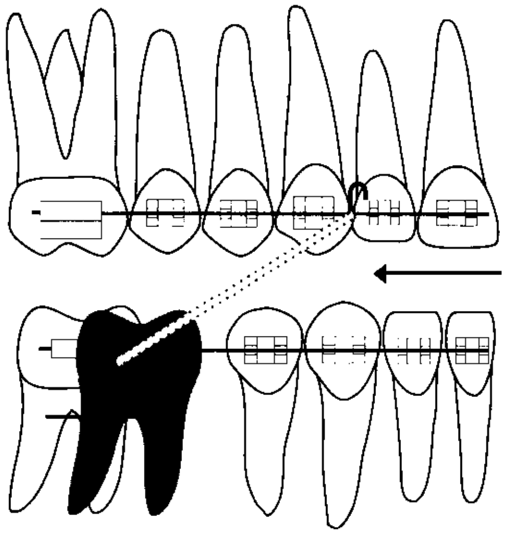

Figure 8.9 Mesial movement of a lower molar using Class II traction

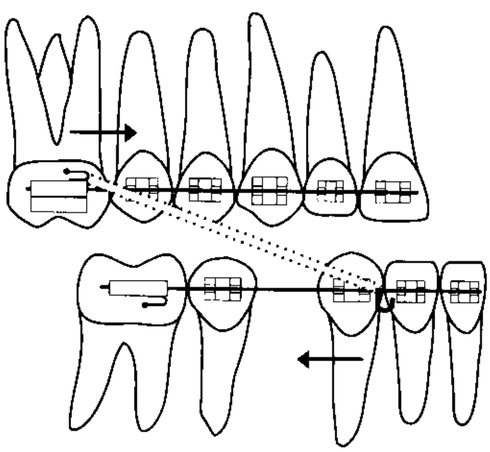

Figure 8.10 Class III intermaxillary traction

the anchorage unit for retraction of the lower incisors (Figure 8.10). Alternately the lower arch can be used to provide anchorage for forward movement of upper buccal segments.

Individual teeth or a group of teeth in either the buccal or labial segments can be made more or less resistant to movement under the influence of class II or class III traction. The methods described for intramaxillary anchorage such as prevention of tipping, and torque control, are equally relevant to the use of intermaxillary anchorage. The orthodontist therefore has a number of methods by which anchorage can be reinforced intra-orally.

Practical aspects of intermaxillary traction

Intermaxillary traction is applied by the use of latex elastic rings. They are available in a range of sizes. The patient is instructed in the hours of wear and the necessity for daily replacement of the bands. Ideally, elastics should provide a continuous force but because they are usually removed for meals and tooth brushing they provide an interrupted force. Excellent patient co-operation is necessary if they are to be effective. The force levels required will depend upon the type of tooth movement that is to be achieved and the relationship of the archwire to the bracket. For tipping movements force levels of approximately 60–100 grams are usually sufficient. If the bracket–archwire relationship restricts tipping, such as when a rectangular archwire is used with an edgewise bracket, additional forces will be necessary to overcome both friction and restriction of tipping. Force levels of 150–200 grams may be more appropriate. The forces applied should be measured using a tension gauge.

It must be remembered that intermaxillary elastic forces will have a vertical as well as a sagittal component of force. The vertical component can cause extrusion of molars and also an increase in overbite with incisor extrusion. Molar extrusion in a Class II case may result in a backward rotation of the mandible.

Because of the vertical extrusive component of intermaxillary elastic traction it is inadvisable to use it until rigid archwires of at least 0.016 in diameter stainless steel are in place. Rigid archwires can to some extent offset the vertical forces. On the other hand flexible archwires would result in uncontrolled tooth movement.

Intermaxillary arch elastics can also be used for the correction of localized crossbites and centre line discrepancies.

Palatal and lingual arches

When space is at a premium the intra-oral methods of anchorage control described above may not be sufficient. Reinforcement of the anchorage will then be necessary. Anchorage may be reinforced within the arches by the use of rigid palatal and lingual arches or, in the lower arch, by using a lip bumper.

Palatal and lingual arches are rigid passive arches attached to molar bands. It is the rigidity of these arches which is one of the factors enabling them to be used to reinforce the anchorage of the molar teeth to which they are attached.

There are a number of effects to be considered:

1. Maintain intermolar width Palatal and lingual arches, by virtue of their construction, will maintain a fixed width across the arch and so reduce the tendency of the molars to move forwards onto a narrower part of the arch.

2. Restrict mesial tipping If space is available molar teeth have a natural tendency to tip mesially. This is particularly so in the lower arch. Palatal and lingual arches soldered to molar bands will restrict this movement. When a force is applied it is only possible for both teeth to move together, which increases their anchorage value.

In the upper arch the anterior section of the palatal arch is in contact with the vault of the palate. Even slight mesial tipping of the molars will result in the arch embedding in the palatal mucosa. An acrylic button can be incorporated onto the anterior section of the palatal arch. This will dissipate forces over a wider area and offer more resistance to mesial tipping of the molars.

3. Maintain arch length Forward movement of the molar teeth is restricted by virtue of the fact that the anterior section of the arch rests either on the palatal vault or on the lingual aspect of the lower incisors. This will not however **prevent** forward movement of molar teeth – particularly in the lower arch where anchorage reinforcement measures are not as efficient in practice as in theory. Molars tend to tip forwards and contact of the lingual arch with lower incisors offers minimal anchorage reinforcement because little force is required to procline the incisors.

Although to a certain extent palatal and lingual arches will maintain arch length they are not able to eliminate all movement of molar teeth.

4. Control of molar rotation and tipping When molar teeth are free to move mesially they do so with an associated rotational movement. The upper molars rotate in a mesiopalatal direction around their palatal root. Lower molars tip in a lingual direction as this is the path of least resistance against the thin lingual plate of bone. Rigid palatal and lingual arches will control upper molar rotation and lower molar tipping and will to some extent restrict forward movement of these teeth.

Uses of palatal and lingual arches

1. Space maintenance

Palatal and lingual arches can be used to limit forward movement of molar teeth following extractions for the relief of crowding. This may allow spontaneous drifting or eruption of crowded anterior teeth into the extraction space while the forward movement of the posterior teeth is restricted.

2. Anchorage reinforcement

The inherent rigidity of palatal and lingual arches which effectively join the molar teeth together afford increased anchorage when used in conjunction with buccal archwires. It must be remembered that rigid arches will not prevent forward movement of the molar teeth.

Palatal and lingual arches are therefore a useful adjunct to single arch intra-oral anchorage reinforcement.

3. Attachment of auxiliaries

Because of their rigidity, palatal and lingual arches can be used for the attachment of auxiliary wires or elastic traction. This can be useful in the management of severely displaced teeth such as palatally placed upper canines. It is quite common either at the time of exposure or shortly afterwards to place an attachment on the unerupted canine. Severe impactions often require distal movement (Figure 8.11), in order to avoid the root of the lateral incisor. As displaced upper permanent canines may need to be moved a considerable distance their anchorage requirements are likely to be significant. Palatal arches can perform the dual function of providing a point of attachment for auxiliaries and reinforcing the anchorage.

Modifications to palatal arches include the transpalatal arch and the quadhelix. The quadhelix is described in Chapter 14. The transpalatal arch (Figure 8.12) is usually made in 0.9 mm hard stainless steel wire and is attached to the molar

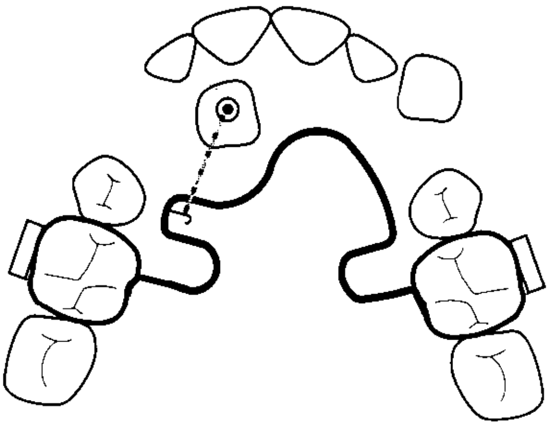

Figure 8.11 Palatal arch with hook and elastic traction to move a palatally impacted canine in a distal direction away from the incisors

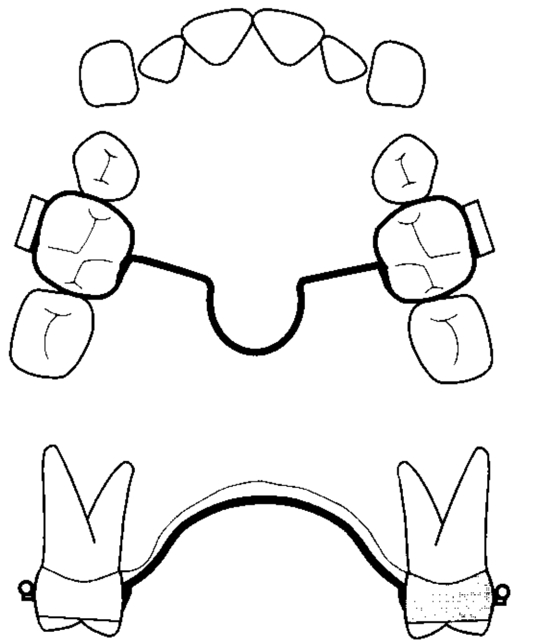

Figure 8.12 Transpalatal arch

bands by either soldering or using a removable attachment. The arch traverses the palate and incorporates a loop for expansion or contraction as necessary. The rigid arch lies approximately 2 mm from the palatal mucosa. The arch is usually designed with the loop pointing distally so that it will not impinge on the palate if mesial tipping of the molars occurs.

Construction of palatal and lingual arches

Palatal and lingual arches are attached to molar bands usually by soldering. They are constructed to the individual patient's requirements and require both clinical and laboratory time to manufacture. At least two, often three, visits are necessary. At the first visit the molar teeth should be separated. Molar bands are selected at the second visit and an impression taken with the bands fitted but not cemented to the teeth.

The molar bands are then removed from the mouth and placed into their correct position in the impression, which is passed to the laboratory for casting. The separators should be replaced to prevent the contact points re-establishing and rendering subsequent fitting of the appliance difficult. The arch is cemented at the third appointment.

Palatal or lingual arches should be constructed of 0.9 mm hard stainless steel wire. Where maximum anchorage is required the arches should be soldered to the molar bands. Such arches are rigid enough to resist distortion in the mouth and maintain arch length and width.

When it is necessary to adjust the arch dimensions, the palatal or lingual arches can be constructed to be removable. There are a number of attachments available which enable the arches to be removed from the mouth without the necessity to remove the cemented molar bands. These attachments are useful when, for example, carrying out intermolar expansion.

Lip bumpers

Lip bumpers are removable arches inserted into accessory tubes on the lower first molars. The anterior section of the arch has an acrylic bumper resting just in front of the lower incisors. The action of the lower lip bumper will result in a distal force being applied to the molars (Plate 10). The arch is constructed in the laboratory from 1.45 mm hard stainless steel wire. When engaged in the molar tubes it should rest in the buccal sulcus approximately 2–3 mm away from the incisor teeth. An adjustment loop in front of the molar tube allows for sagittal and vertical adjustment.

Lip bumpers have a limited application but can be useful in maintenance of lower arch length and for increasing the anchorage potential of the lower molars. The lower incisors may procline as a result of the lower lip being held out of

contact with the labial surface of the lower incisors. In some clinical situations, such as retroclined incisors due to persistent habits or an abnormal soft tissue environment, this forward movement can be desirable. Lip bumpers are not soldered to the molar bands and are removable. The patient is generally instructed to wear the appliance full time.

Clinical management

Palatal and lingual arches, together with their modifications, are well tolerated by patients.

Palatal arches, especially those without an acrylic button, may embed into the palatal mucosa if the molars tip excessively. This usually only occurs when the molars are being used as an inadequate anchorage unit for other tooth movements, or if excessive forces are used.

When used with buccal archwires palatal and lingual arches need to be removed towards the end of treatment to allow final space closure and detailing of the occlusion. This is best managed by removing the arch and bands from the mouth. The arches are cut off and the molar bands stoned and polished before being recemented to the teeth.

Intra-oral anchorage management of malocclusion

Class I malocclusion with crowding

When there is severe crowding, extraction choice would usually favour teeth near to the site of crowding. This choice will reduce the amount of tooth movement required. If premolars are extracted and the canines are mesially inclined they should be allowed to upright spontaneously as this will not place demands upon the anchorage. If space is at a premium, intra-oral anchorage reinforcement methods such as palatal and lingual arches should be considered.

In order to reduce the strain placed upon the anchorage, it is usually wise to retract teeth individually rather than carry out numerous tooth movements at the same time.

As many teeth as practical should be incorporated into the anchorage unit. Banding second molars is often helpful.

In severely crowded cases, intra-oral anchorage may not be sufficient and extra-oral forces may be necessary in order to reinforce the anchorage.

Palatal and lingual arches can be used in the mixed dentition to preserve space for developing permanent teeth.

Hypodontia and class I malocclusion with spacing

Malocclusions in which there is excess space to be closed, perhaps associated with congenital absence of permanent teeth, present particular problems of treatment planning and anchorage management. When the possibility of prosthetic replacement of teeth is being considered it is usually advisable to seek a specialist restorative opinion before finalizing the orthodontic treatment plan.

In some cases it will be decided to close spaces in the arch by moving teeth into contact, avoiding the need for a crown, bridge or denture. In Class II division 1 cases overjet reduction will utilize maxillary arch space, but it will usually be necessary to move buccal segment teeth forwards. Significant forward movement of buccal teeth places considerable demands upon anchorage, and when the anterior teeth are acting as the anchorage unit they are in danger of being moved too far in a lingual direction. Separate forward movement of the buccal teeth is advisable, and intermaxillary traction may be useful to provide anchorage from the opposing arch.

Elastic thread or coilsprings can be used to slide teeth along the archwire into contact. The first stage involves closure of spaces between the incisors and canines. Careful attention to centre line management is important, and this is a particular problem when the malocclusion is markedly asymmetric. When anterior space closure is complete the incisors and canines are tied together with wire ligature before moving the buccal teeth forwards. When all space closure has been achieved the teeth are ligated together. Archwires of progressively increasing size may then be used to correct angulations and detail the occlusion.

In severe cases, where significant space closure is necessary, extra-oral protraction headgear may be used in the maxillary arch to supplement anchorage.

From the point of view of stability it will be important to close all the spaces in the arch. Closure of spacing by orthodontic means is particularly liable to partial relapse, and serious consideration must be given to long-term retention (Chapter 15).

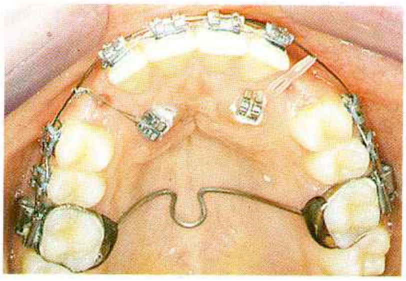

Plate 1 Brackets bonded to palatally placed canines, allowing the application of orthodontic forces to the teeth

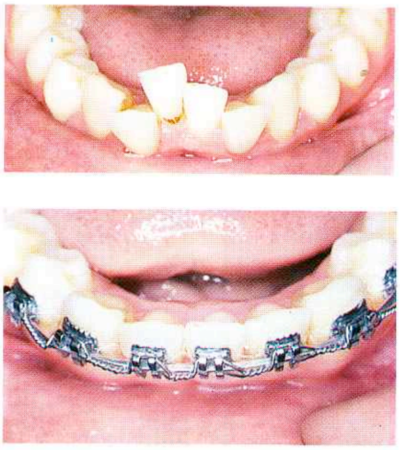

Plate 2 Alignment of a lower labial segment with a fixed appliance, following extraction of a displaced incisor

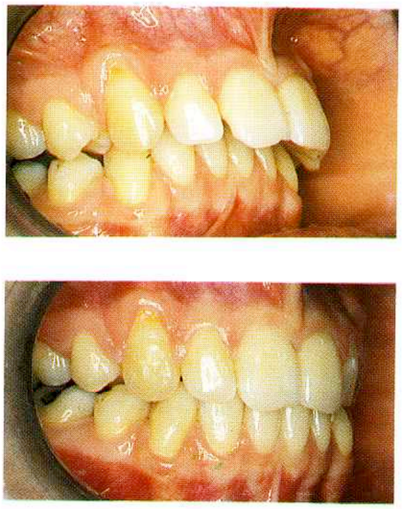

Plate 3 Overjet reduction. Fixed appliances have been used to retract the incisors bodily

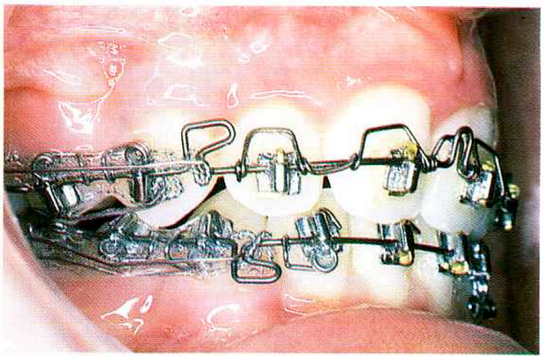

Plate 4 Begg appliance – uprighting springs on the canines and torqueing auxiliary on the incisors

Plate 5 Ceramic brackets

Plate 6 Attachments for bonding on to displaced teeth. Cleat, button and eyelet.

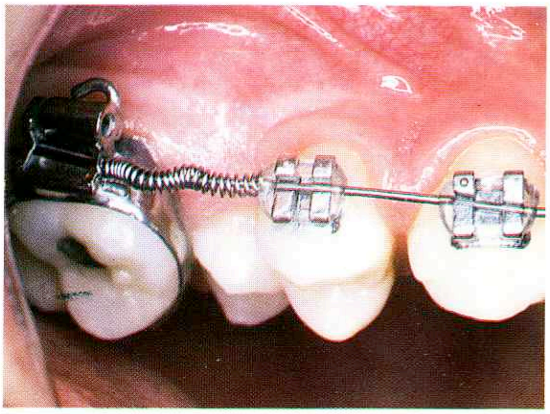

Plate 7 Compressed coil spring to open space

Plate 8 Mesh base of bracket

Plate 9 Separation using elastomeric rings

Plate 10 Lower lip bumper to restrict forward movement of lower molars

Plate 11 High pull headgear with 'J' hooks.

Plate 12 Cervical neck strap with 'snap-away' mechanism

Plate 13 Interlandi headgear with Masel safety strap

Plate 14 High-pull headgear with 'snap-away' safety modules

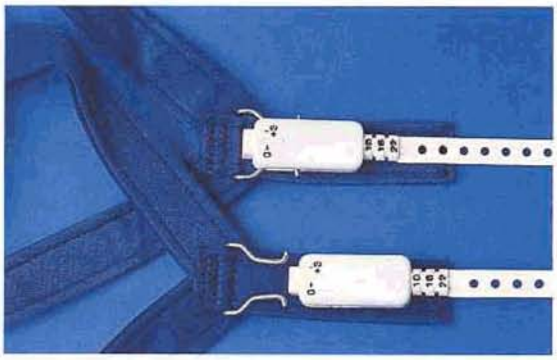

Plate 15 Spring loaded headgear mechanism

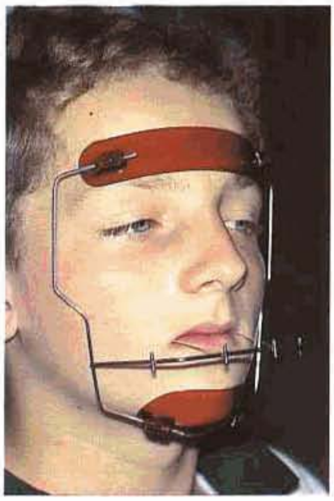

Plate 16 Protraction headgear

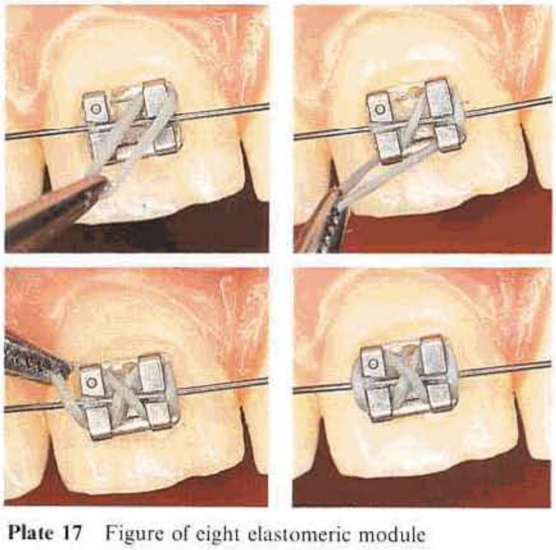

Plate 17 Figure of eight elastomeric module

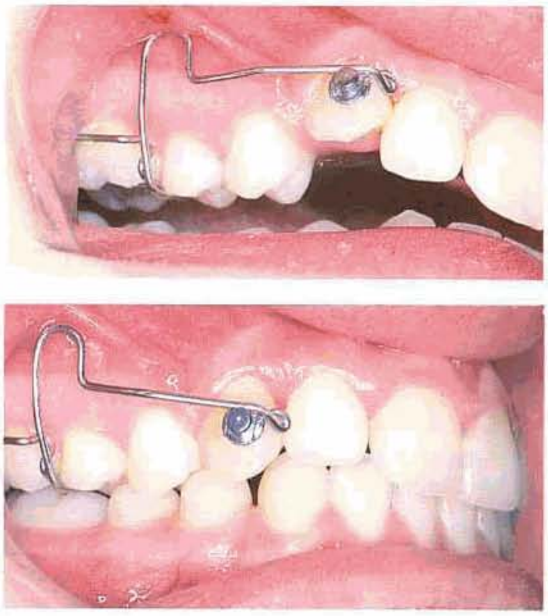

Plate 18 An upper removable appliance may be used with a bonded attachment on a partially erupted canine to bring the canine into the arch

Plate 19 A traction ligature to apply a force from the molar hook to the archwire

Plate 20 The circle hook in the sectional buccal archwire acts as a guide for the elastic thread and ensures the correct application of the force to bring the canine buccally

Plate 21 Locking device for a removable palatal arch

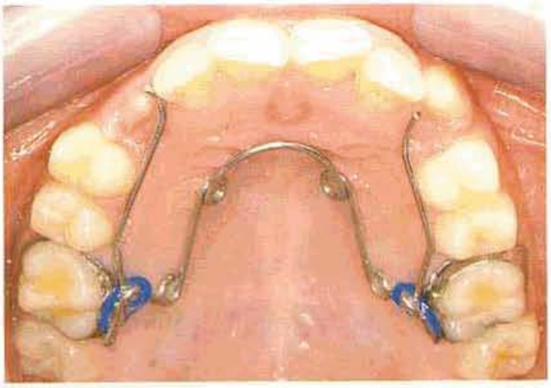

Plate 22 Quadhelix

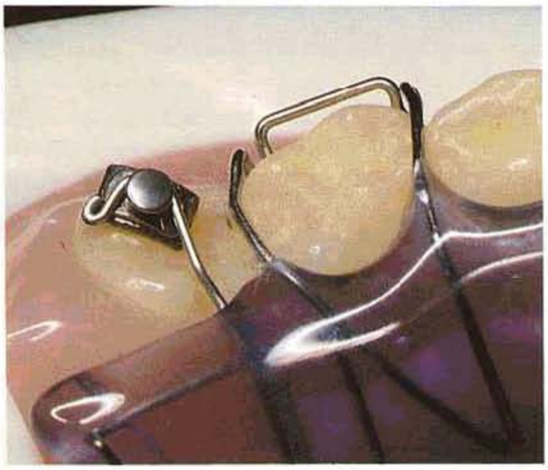

Plate 23 A removable appliance to disimpact an upper first molar

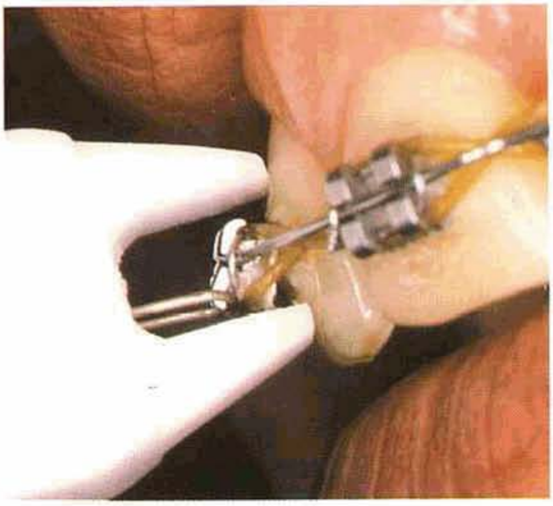

Plate 24 Bracket removal with lift-off plier

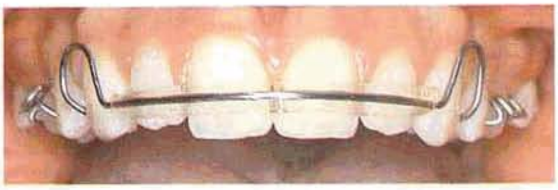

Plate 25 Retainer with labial acrylic overlay

Plate 26 Decalcification associated with a loose molar band

Class II division 1 malocclusion

In Class II cases where there is crowding and an increased overjet to reduce, the anchorage necessary will be influenced by the amount of tooth movement required, the choice of extractions and the resulting space that will be available in the dental arches.

Because of their large root area the canines are usually retracted first to reduce the demands on the posterior anchorage. Although some edgewise techniques retract both the canines and incisors together following their alignment, this places heavy demands on the anchorage and extra-oral reinforcement is usually necessary.

The inclination of the canine will determine the anchorage requirements. While mesially inclined canines tend to upright spontaneously, upright and distally inclined canines place greater demands upon the anchorage and commonly more than is available by intra-oral methods alone.

Proclined upper incisors can be retracted using round archwires which, in an edgewise bracket channel, place minimal demands on the anchorage as tooth movement is achieved by tipping. Upright or retroclined incisors require apical control in order to reduce the overjet without further retroclination.

Apical control with a close-fitting rectangular archwire in an edgewise bracket will be achieved either by torsion applied by the archwire or, alternatively, by the torque values built into the bracket channel in a preadjusted appliance system. A force couple is set up within the bracket channel.

Apical control with round wires can be achieved by tipping the teeth palatally and subsequently uprighting them. This is achieved in the Begg appliance by setting up a force couple on the labial surface of the tooth with a torqueing auxiliary archwire (Chapter 13).

The technique of tipping then uprighting appears to place less demands upon the anchorage than bodily movement with rectangular wire in an edgewise bracket.

Class II traction will aid overjet reduction but will also have an influence on the lower arch, applying a mesial force to the lower posterior teeth. It is important to ensure that this force is not transmitted to the lower incisors which will then tend to procline. If this is to be avoided intramaxillary traction in the lower arch may be applied from a hook on the archwire distal to the incisors to the hook on the molar band.

If forward movement of lower posterior teeth is to be resisted either anchorage bends placed in the archwire mesial to the molars or a rigid lingual arch may be used.

If there are no spaces in the lower arch and all teeth are bonded, mesial movement against class II traction can be restricted with the use of full thickness rectangular archwire. Inhibition of the freedom to tip will restrict unwanted mesial movement of the buccal teeth.

Space closure may be necessary in the final stages of treatment. Rigid rectangular wires of 0.019 in occluso-gingival dimension should be used to prevent unwanted tipping and consequent binding of the bracket channel against the archwire. A force of sufficient magnitude is necessary to overcome friction. It has been suggested that a light continuous force is more effective in achieving space closure than an intermittent force. Nickel-titanium coilsprings appear to be more efficient than elastic traction methods.

Class II division 2 malocclusion

In the management of a Class II division 2 malocclusion overbite reduction is invariably necessary (Chapter 12). This can be difficult to achieve and will place demands upon the anchorage. Commencement of treatment with an upper removable appliance incorporating an anterior bite plate will serve two functions. Firstly it will aid overbite reduction and secondly it will enable clearance of the incisors to allow bracket placement. Alignment of the lower arch is a first priority in order that stainless steel archwires with anchorage bends can be utilized. Anchorage bends (Figure 8.5) will apply an intrusive force to the incisors with a resultant extrusive force on the molars. Some extrusion of the lower molars can be allowed as this will contribute to overbite reduction. Many Class II division 2 malocclusions are treated without resorting to extractions, particularly in the lower arch, and some proclination of the lower incisors is usually desirable. If the lower incisors are retroclined a lower lingual arch activated in an anterior posterior direction can be useful in maintaining arch length and encouraging some uprighting of the incisors.

In Class II division 2 malocclusions crowding of the upper arch is usually restricted to the upper labial segment. Space is required for the alignment of the crowded lateral incisors. Distal

movement of the buccal segments may be the most appropriate method of creating sufficient space for the correction of the lateral incisor position. Although removable appliances can be used to move teeth individually, the demands upon the anchorage are considerable. Distal movement is best carried out with the use of extra-oral forces.

Class III malocclusion

In Class III malocclusions it is usually desirable to allow the upper incisors to move forwards while retroclining the lower incisors. This is often best achieved by tipping of the incisors with the use of round archwires. In order for the corrected incisor relationship to remain stable a positive overbite must be established. The use of anchorage bends is therefore not appropriate in the correction of a Class III incisor relationship. If space closure in the upper arch is necessary the upper incisors must not be allowed to retrocline. Intramaxillary forces used in the upper arch results in forward movement of the molars but risks unacceptable palatal movement of the incisors. For this reason intramaxillary traction will need to be used with caution. In the lower arch intramaxillary forces will tend to retrocline the lower labial segment which is advantageous.

Class III intermaxillary traction is appropriate because it will encourage lingual movement of the lower incisors and reciprocal forward movement of the upper buccal segments.

To achieve forward movement of the upper incisors a stopped arch should be used (Figure 8.13). As the molars move forward the incisors will also move anteriorly with the archwire.

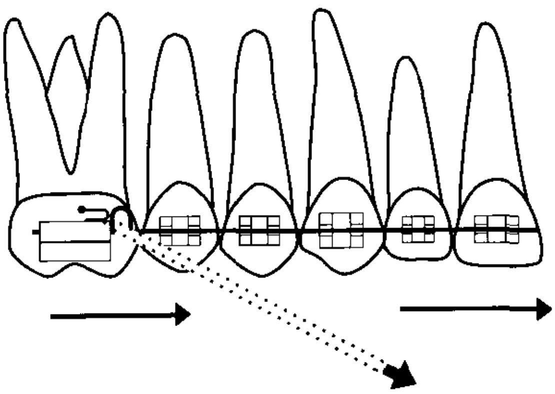

Figure 8.13 The Class III traction will move the molar and the archwire forwards, when a 'stopped arch' is used

Centre-line correction

In order to achieve correct interdigitation of the teeth the centre-lines of the upper and lower dental arches must be coincident at the completion of treatment. In addition, significant displacement of the dental centre-line, particularly in the maxillary arch, may be aesthetically unacceptable.

Correct positioning of the centre-lines can be difficult to achieve, and requires consideration at the treatment planning stage. In some cases, it will be necessary to move the centre-line in only one arch, whereas in other cases both centre-lines need to be repositioned, often by different amounts. Significantly asymmetric malocclusions inevitably present problems in appliance management because they demand the application of asymmetric forces, with consequential anchorage complications.

Before commencing treatment the mesiodistal angulation of the teeth in the labial segments should be assessed.

Sometimes the teeth will be tipped towards the direction in which the centre line has moved. In such cases, providing space is made available, the centre-line will improve as the anterior teeth become more upright. This helpful tendency should be remembered, and utilized when the fixed appliance is fitted. Space should be made available so that when the angulation of anterior teeth is being corrected favourable movement of the centre line is achieved.

In other cases the centre-line discrepancy is not associated with tooth angulations which are favourable. Centre-line correction is then much more difficult to achieve, requiring careful space management and complex anchorage consideration.

Centre-line correction is closely associated with management of space in the dental arches. It is always important to achieve correction, with the teeth at their correct angulation, before all the available space has been used.

In all cases, centre-line management demands attention throughout treatment because improper mechanics can easily cause asymmetry to develop.

The utilization of **favourable** anterior tooth angulations as described above will be made difficult if edgewise brackets are in use. In the initial stages of treatment when the anterior teeth are crowded, the archwire will apply forces tending to improve the angulation of the anterior

teeth. Improvement in angulation will tend to occur without favourable movement of the centre line because no space is available into which the crowns can move. In this situation it may be advisable to create space by asymmetric canine retraction before attaching the incisors to the archwire.

There are a number of other mechanical approaches to centre-line correction:

1. *Moving both upper and lower centre-lines using an anterior cross elastic* (Figure 8.14) This is a useful approach when both centre-lines need correction – but careful supervision is required because it is unlikely that the anchorage balance will result in correct positioning of both centre lines – although they may become coincident. The vertical component of the anterior elastic tends to produce asymmetric tipping of the occlusal plane, and archwires of sufficient size must be used to restrict this unfavourable movement.
2. *Moving anterior teeth along the archwire* Figure 8.15 shows the use of a compressed coilspring which is applying a force to correct the centre-line. The reciprocal of this force is in danger of producing unfavourable movement of the canine, and steps must be taken to prevent this tooth moving buccally and distally. The archwire must be of sufficient size to restrict tipping of the incisors as they move along the archwire. In Figure 8.16 the anterior teeth are being moved along the archwire separately using linked elastic modules or elastic thread.
3. *Asymmetric intramaxillary and/or intermaxillary elastic traction may be used to provide different forces each side of the arch.* By itself it is rarely a satisfactory method of correcting a centre-line discrepancy. However, it can be useful in augmenting other methods described above.

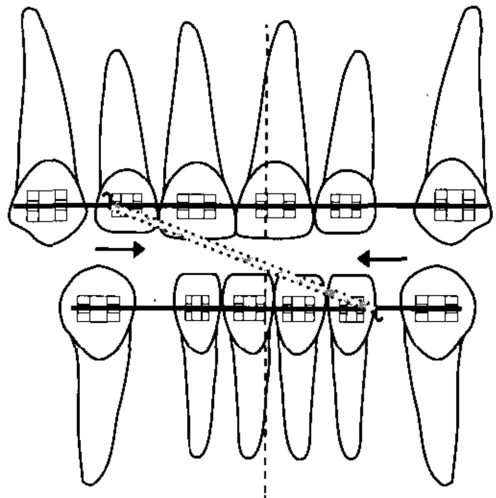

Figure 8.14 Centre-line correction with anterior cross elastic

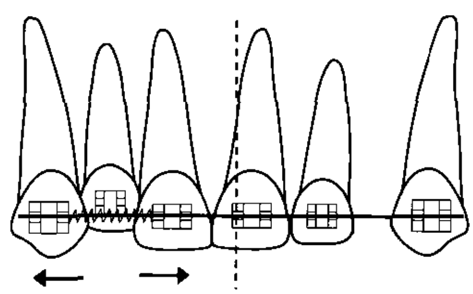

Figure 8.15 Single-arch centre-line correction with a compressed coilspring

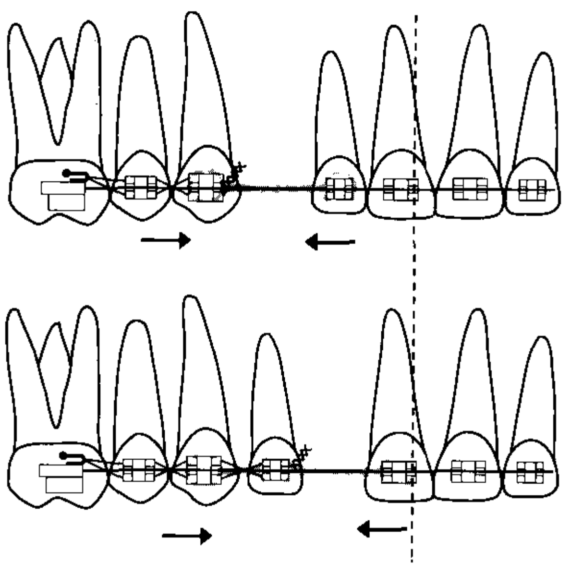

Figure 8.16 Centre-line correction using elastic modules to move teeth individually. The teeth in the anchor unit are ligated together

Begg brackets permit tipping and relatively rapid initial movement of the anterior teeth, and

centre-line improvement will occur as favourably angulated teeth become more upright.

The possibility of using uprighting springs with Begg brackets confers considerable versatility. Uprighting springs can be applied to individual teeth in order to achieve centre-line correction. On the other hand it may be difficult to achieve and retain precise angulation of the teeth. The Tip-Edge development of the Begg bracket is designed to overcome these difficulties, at the same time retaining many of the system's useful features.

Further reading

Grossen, S. and Incervall, B. (1995). The effect of a lip bumper on lower dental arch dimensions and tooth positions. *European Journal of Orthodontics*, **17**, 129–34.

Osbourne, W. S., Nanda, R. S. and Frans Currier, G. (1991). Mandibular arch perimeter changes with lip bumper treatment. *American Journal of Orthodontics and Dentofacial Orthopedics*, **99**, 527–32.

Samuels, R. H. A., Rudge, S. J. and Mair, L. H. (1993). A comparison of the rate of space closure using a nickel-titanium spring and an elastic module: a clinical study. *American Journal of Orthodontics and Dentofacial Orthopedics*, **103**, 464–7.

9

Extra-oral anchorage

Forces used to produce tooth movement are derived from anchorage provided intra-orally or extra-orally. In many cases both intra- and extra-oral anchorage are in use at the same time.

The principal use of extra-oral anchorage is to augment intra-oral anchorage, so enabling tooth movement which would not be possible using intra-oral alone.

The forces derived from extra-oral anchorage can be used to:

- stabilize the position of teeth to which they are applied; distally directed extra-oral forces can for instance be delivered to upper first molars with the intention of preventing mesial movement of the molars;
- produce mesiodistal, vertical and angular changes in tooth position;
- produce an 'orthopaedic' change.

When extra-oral force is used to stabilize the position of teeth the term 'extra-oral anchorage' (EOA) is sometimes used, whereas when it is used to achieve tooth movement 'extra-oral traction' (EOT) is used.

There are many malocclusions in which intra-oral anchorage will be sufficient to allow satisfactory tooth movement to be caried out. Cases with severe crowding or a significantly increased overjet which requires bodily tooth movement to correct, will probably require extra-oral reinforcement of the anchorage. Alternatively where the space available (even with anchorage reinforcement) is insufficient, additional space may be obtained by distal movement of the buccal segments. This can be achieved by using extra-oral appliances. Extra-oral appliances can also be used in the treatment of mild malocclusions where only small amounts of space are required and extraction of teeth would not be appropriate.

The advantages of extra-oral forces are that the anchorage potential is almost infinite and the magnitude and direction of force can be varied according to the clinical needs. Patient compliance may however be a limiting factor. The force is generated from a headcap or neckstrap by a variety of means such as elastic bands, springs or elasticated webbing. The force is usually delivered to the teeth by means of a facebow which fits into tubes on the molar bands. Various tooth movements can be carried out depending upon the design and adjustment of the facebow. The molar teeth to which the facebow is attached can be maintained in their sagittal position, moved distally, intruded, extruded and rotated.

Methods of applying extra-oral force

Facebow

The facebow is the most commonly used method of applying extra-oral force to the dentition. It consists of an inner bow which engages tubes on the molar bands and an outer bow which is attached to the headgear. In order to prevent the facebow sliding through the tube a stop is necessary in front of the molar tube. Most facebows carry an adjustment loop which also acts as a stop (Figure 9.1). Some manufacturers

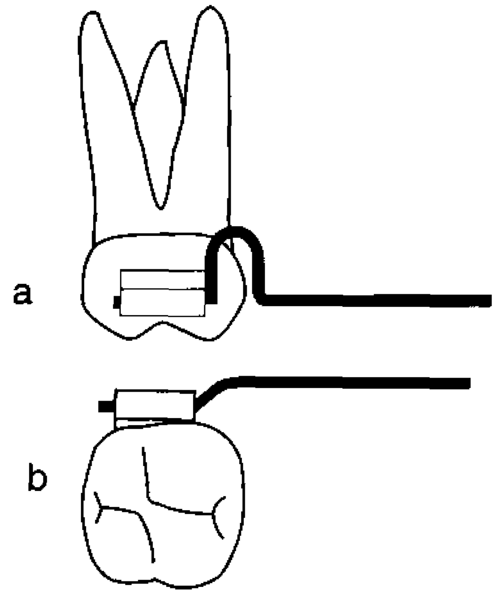

Figure 9.1 Facebow stops: (a) facebow with 'U' loop; (b) facebow with bayonet bend

produce molar tubes which incorporate a distal stop at the end of the buccal tube. With these tubes the facebow does not require stops or bends. However, an adjustment loop is useful for adaption of the inner bow as treatment progresses, particularly when distal movement of the molars is undertaken.

'J' hooks

An alternative method of applying extra-oral forces to a fixed appliance is to use hooks from a headgear (Plate 11). The hooks are termed 'J' hooks on account of their shape and are attached directly to the archwire usually in the incisor region (Figure 9.2). The extra-oral force, which is in an upward and backward direction, can be used to assist in overjet reduction or intrusion of the incisors.

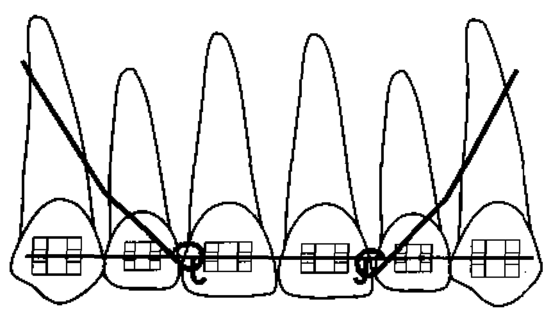

Figure 9.2 'J'-hook traction engaged in stops soldered or crimped onto the archwire

Directional control of extra-oral forces

The effects of extra-oral forces are related to their direction, magnitude and duration, but the large number of variables associated with the design of extra-oral appliances makes for difficulties in understanding their mechanical action.

The mechanics of directional control are complex, but they need to be understood if the appliance is to produce the required result.

Consideration of the mechanisms associated with the application of extra-oral forces to upper molars by means of a facebow will illustrate the important general principles.

Angular change, translation, and the centre of resistance

Consider first the theoretical situation in which a molar tooth is free to rotate around a fixed axis situated at the root trifurcation (Figure 9.3). When a force is applied the tooth will rotate either clockwise or anticlockwise, according to the relationship between the direction of the force and the axis. The axis is the **centre of**

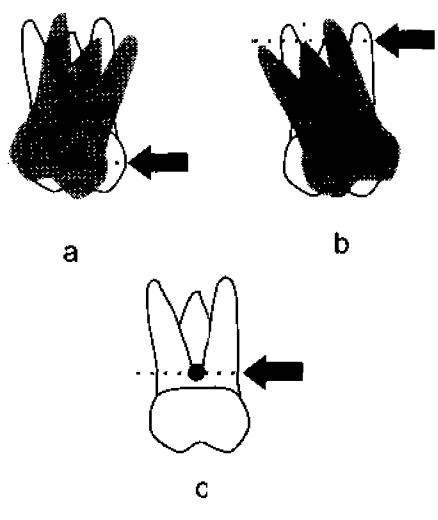

Figure 9.3 Theoretical situation in which force is applied to a molar which is only free to rotate around a fixed axis. The tooth rotates clockwise (a) or anticlockwise (b) according to the relationship between the force direction and the axis. In (c) the force direction is in line with the axis, and no rotation occurs

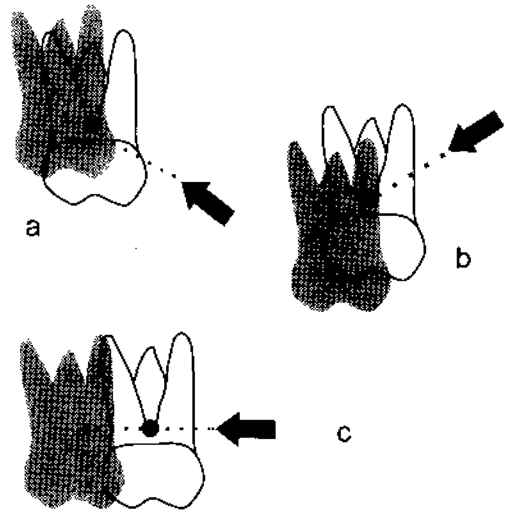

Figure 9.4 Force application in line with the centre of resistance. In each case the tooth translates without angular change. (a) The tooth moves upwards; (b) the tooth moves downwards; (c) the direction of force is parallel to the occlusal plane

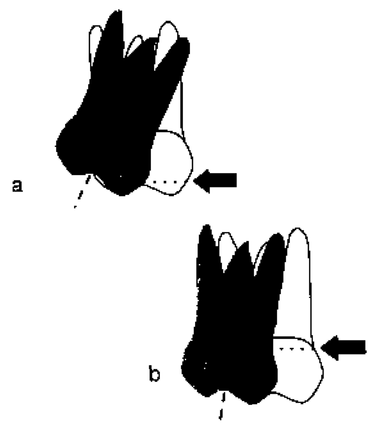

Figure 9.5 The effect of the distance between the centre of resistance and the direction of force. In (a) the distance is large, and the angular change is greater than in (b) where the distance is small

rotation. If the force is exactly in line with the axis the angulation of the tooth will not change.

The clinical situation differs from that described above in that there is no fixed centre of rotation, and the tooth can be considered a 'free body'. The molar tooth will offer resistance to the force applied, but now the whole tooth is free to move in the direction of the applied forces – in other words, the tooth can translate in addition to demonstrating angular change. The resistance offered by the tooth to both translation and angular change can be resolved at a single point known as the **centre of resistance**. In practice it is impossible to determine the exact position of the centre of resistance, but it can be assumed to lie at the trifurcation of the molar root.

If the direction of the force is in line with the centre of resistance the tooth will translate without angular change (Figure 9.4). The tooth will also move vertically unless the force direction is parallel with the occlusal plane.

If the direction of force is not in line with the centre of resistance the tooth will show both angular change and translation (Figure 9.5).

The relative amounts of angular change and translation are determined by the length of the shortest distance between the line of force and the centre of resistance. If this distance is large (Figure 9.5(a)) there will be relatively more angular change and less translation. If the distance is small (Figure 9.5(b)), there will be relatively more translation and less angular change.

Direction of extra-oral forces and upper molar movement

The factors influencing the direction of forces applied to the molars are as follows:

- the direction of the extra-oral force;
- the length of the external arm of the facebow;
- the angulation of the external arm of the facebow relative to the intra-oral section of the facebow, in the horizontal plane.

Rather than considering in detail all the possible combinations of variables, some specific clinical uses will be described to illustrate the control of molar movement, based on low, medium- and high-pull headgears. However, the reader will be able to apply the principles outlined above to any possible combination. The essential issue is the relationship between the direction of the extra-oral force and the centre of resistance of the molar.

In order to assist understanding it is assumed in the following examples that the inner arch of the extra-oral facebow fits passively in the molar tubes, and that the facebow is rigid and will not bend under the influence of forces applied.

Headgear

Headgear appliances are often described by their relationship to the occlusal plane, which can be

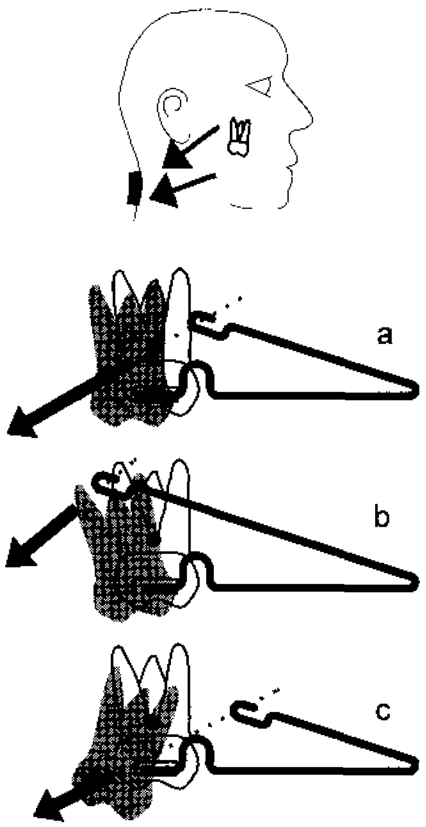

Figure 9.6 Low-pull headgear: (a) the line of force passes through the centre of resistance and the molar translates without angular change; (b) the line of force passes above the centre of resistance and the tooth rotates anti-clockwise; (c) the line of force passes below the centre of resistance and the tooth rotates clockwise. In all cases the tooth moves downwards

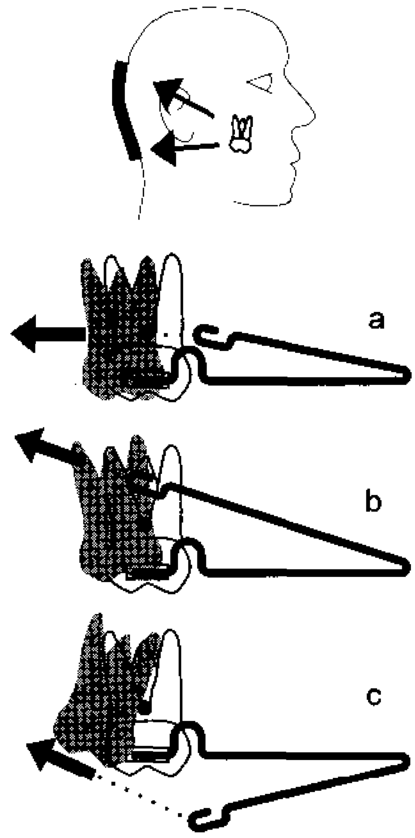

Figure 9.7 Medium-pull headgear: (a) the line of force passes through the centre of resistance, and is parallel with the occlusal plane; (b) the line of force passes above the centre of resistance; the tooth moves upwards, and rotates anticlockwise; (c) the line of force passes below the centre of resistance; the tooth moves upwards, and rotates clockwise

either in line with the occlusal plane (medium-pull), above the occlusal plane (high-pull) or below the occlusal plane (low-pull).

Low-pull headgear

Low-pull headgear is provided by a cervical neckstrap (Plate 12), which produces a direction of force that will tend to extrude the molars.

In Figure 9.6(a) the outer arm of the facebow is angled upwards, and its length is such that the line of force passes through the centre of resistance. The molar will move distally without angular change.

If the outer arm is lengthened (Figure 9.6(b)) the molar will move distally and rotate anti-clockwise. If the outer arm is shortened (Figure 9.6(c)) the molar will move distally and rotate clockwise.

In all cases, it should be noticed that an extrusive force is applied to the molar. It is not possible when using a cervical neckstrap to apply a force parallel to, or angled upwards with respect to, the occlusal plane. Extrusion of upper molars might be considered desirable in patients with a low maxillary mandibular planes angle, but undesirable when that angle is already increased or when the overbite is reduced. Low-pull headgear is principally used as anchorage reinforcement.

Medium-pull headgear

Medium-pull headgear allows a considerable freedom in determining the direction of force,

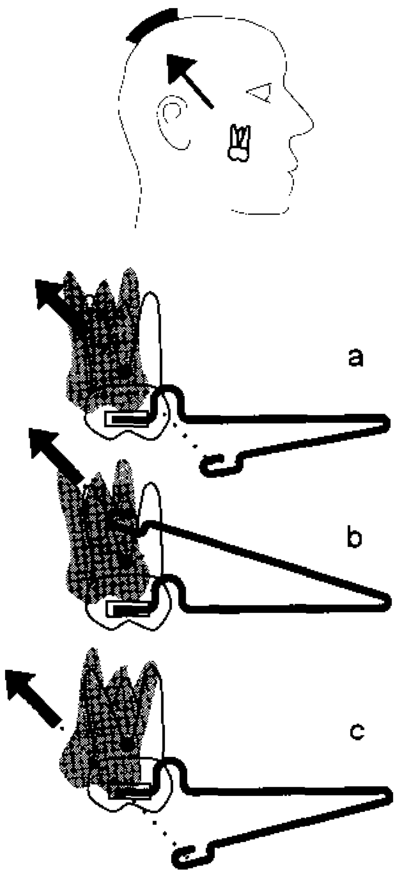

Figure 9.8 High pull-headgear: (a) the line of force passes through the centre of resistance and the molar translates without angular change; (b) the line of force passes above the centre of resistance and the tooth rotates anti-clockwise; (c) the line of force passes below the centre of resistance and the tooth rotates clockwise. In all cases the tooth moves upwards

and is the most widely used type. A particularly adaptable design, and one which is comfortable and convenient for the patient, is the 'Interlandi' headgear (Plate 13).

In Figure 9.7(a) the direction of force is parallel with the occlusal plane. The external arm of the facebow is angled upwards and the line of force passes through the centre of resistance. The molar moves distally without angular change or vertical movement.

Even though the molar does not move downwards relative to the occlusal plane, there will be a tendency to increase the maxillary mandibular planes angle as the molar moves distally. If an increase in the maxillary mandibular planes angle is to be avoided an intrusive force must be applied to the molar. This can be achieved by bending the outer arm of the facebow downwards and arranging the direction of the extra-oral force so that it is in an upwards direction while still passing through the centre of resistance.

If the direction of force does not pass through the centre of resistance the tooth will tip as it moves distally (Figures 9.7(b), 9.7(c)).

The application of a small upwards force with a clockwise rotation (Figure 9.7(c)) is particularly useful when moving molars distally if the molars are mesially inclined before retraction and if change in the maxillary mandibular planes angle is to be minimized.

High-pull headgear

High-pull headgear (Plate 14) inevitably applies an intrusive force to the molar, tending to reduce the maxillary mandibular planes angle. This effect may be considered of advantage in patients with an increased maxillary mandibular planes angle, but undesirable when that angle is low, or when the overbite is increased.

If the line of force passes through the centre of resistance (Figure 9.8(a)) the molar will translate distally and upwards. If the line of force does not pass through the centre of resistance the molar will tip as it moves distally and upwards (Figures 9.8(b), 9.8(c)).

Magnitude of force

Force levels must be carefully controlled in order to produce the correct amount of tooth movement. Force levels of 300–500 grams each side are usually sufficient, with the higher figure required for distal movement. In order to ensure that the correct amount of force is being applied a strain gauge should be used. Some commercial headgears have a force level indicator built into the traction spring but the use of a strain gauge is still advised. Excessive force levels will result in the appliance being difficult to place and the patient will very quickly complain of discomfort.

Duration of force

Ten hours of wear in each 24-hour period is sufficient to prevent forward movement of molars. Active distal movement of molar teeth will require force levels at the upper end of the

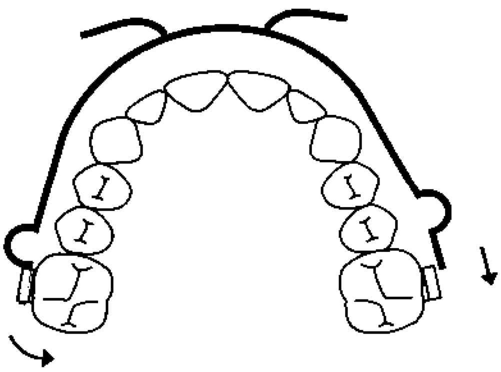

Figure 9.9 Adjustment of the inner arch is required to engage the facebow passively

force range for maximum duration. It is customary to expect the patient to wear headgear appliances for at least 14 hours a day if any significant distal movement is to be achieved.

Practical aspects

Fitting the facebow

The facebow engages in the larger tube on the upper molar bands. Because of the magnitude of the forces utilized it is essential that molar bands are a good fit. The use of headgear with bonded molar tubes rather than bands is considered by the authors to be dangerous and is not recommended.

Adjustment of the facebow will almost certainly be necessary in lateral, vertical and horizontal planes.

Inner bow

It is important to realize that the inner arm of the facebow can act as an independent appliance. This can be used to advantage during the application of extra-oral forces but, on the other hand, if the inner bow is not correctly adjusted it will produce unwanted tooth movements. Initially the facebow should fit passively in the molar tubes. Facebows are available in a range of sizes and types. Those incorporating 'U' adjustment loops are preferable. An appropriate size of facebow should be chosen by comparing it with the upper reference model.

In the mouth, one end of the facebow should be placed in a molar tube and an assessment made to ensure it matches the size and shape of the archform. Lateral adjustments should be made to the short end of the inner bow in order that the opposite side approximates to the molar tube. These adjustments are best made using a pair of universal pliers. The bow may need to be retried in the mouth on a number of occasions before a passive fit is achieved. The bow should then be repositioned in the opposite tube. Adjustment to this section may then be necessary to ensure there are no rotational, tipping, expansion or contraction forces built into the facebow (Figure 9.9). The bow should not touch any teeth except the molars.

The anterior section of the bow should rest between the lips when the patient is relaxed. A facebow which impinges on the upper or lower lip will be uncomfortable. Vertical adjustments can be made along the inner arm of the bow. These alterations are usually made in the 'U' loops in front of the molar tubes. Small alterations will have a significant change at the anterior end of the bow.

The final adjustment of the bow in the vertical plane can only be made when the headgear has been fitted and tested, as the tension may influence the height of the anterior part of the bow.

If a facebow is used which does not have adjustment loops then either a bayonet bend or a stop at the end of the molar tube is necessary to deliver the force to the molar. The length of the facebow can be adjusted by cutting the end and trimming to the required length. It is not possible to lengthen facebows which do not have a 'U' loop. Once the molars have moved distally the anterior part of the facebow may impinge on the incisors and a new facebow with a longer inner arm will have to be fitted.

The ends of the facebow must be made smooth and rounded in order to reduce the possibility of injury to the patient should it become displaced.

Outer bow

Facebows are manufactured with differing lengths of the outer arm. In general, a short outer arm is best with the outer bow the same length as the inner bow.

The length of the arm may be reduced by bending a new hook but heavy-duty pliers are required to bend the thick wire. For routine use with a medium-pull headgear the hook is best positioned just anterior to the upper first molar.

The outer arm of the facebow should be adjusted so that it is close to but not touching the cheeks. The end of the hook must be smooth so as not to catch on bedclothes or be a potential cause of trauma.

Fitting the headgear

The correct size of headgear should be chosen. Adjustment may be necessary to ensure that the appliance fits firmly and is comfortable for the patient. Neckstraps are usually available in one size.

The force to the facebow is provided either by springs which are incorporated into the 'snap away' adjustable side pieces (Plate 15), or by elastics as in the case of Interlandi headgear (Plate 13), or, in the case of neckstraps, by elasticated webbing. When elastics are used, the appropriate size should be chosen and the patient instructed in their use and advised of the need for replacement every few days. The force delivered by elasticated webbing can be adjusted using sliding clips.

The use of a safety device is mandatory when a facebow is in use. Serious injury has been caused to patients in the following circumstances:

1. When the facebow is forcibly pulled forwards against the applied force and then released. In this case a 'catapult' injury may occur, and if the inner bow has become displaced out of the mouth the patient may suffer serious injury to the face or eye. The 'snap-away' type of force module, if functioning correctly, will avoid this kind of accident.
2. When the facebow becomes displaced from the mouth, perhaps when the patient is asleep, and comes to lie on the pillow in a position where the end of the bow can cause a penetrating injury when the patient turns their head. The 'snap-away' type of force module will not avoid this type of injury. A non-elastic safety strap running round the back of the neck and firmly attached to both ends of the outer bow will prevent inadvertent removal of the facebow from the mouth, and this is the safety method recommended by the authors. The patient must be made proficient in the use of the safety device, and the instructions given must emphasize the importance of using it.

Uses of extra-oral anchorage

Anchorage reinforcement

1. Upper arch

Extra-oral forces are often used to reinforce intra-oral anchorage. This is usually achieved by preventing forward movement of the molars. Approximately 10 hours' daily wear of the headgear will be necessary. A force value of 300 grams each side is usually sufficient.

2. Lower arch

It is sometimes necessary to reinforce anchorage in the mandibular arch. It is difficult to apply extra-oral traction to the lower arch and it is not well tolerated by patients. An alternative is to transfer the extra-oral force to the lower dentition by the use of class III intermaxillary traction. The intra-oral elastics should only be applied at the same time as the headgear is worn. The headgear will compensate for the mesial force applied to the upper molars by the class III traction. It should be remembered that class III intermaxillary traction will apply an extrusive and mesial force to the upper molars. It is therefore necessary to ensure the headgear is adjusted so that it does not also tend to extrude the molars.

Space maintenance

Because an extra-oral force will prevent forward movement of the molars it is a most efficient method of maintaining arch length. It can be used as a space maintainer following the relief of crowding. When utilized in this way the extra-oral appliance will only need to be worn for approximately eight hours each day. When the facebow is in the mouth there is minimum interference with erupting or crowded teeth. An important advantage in the use of extra-oral forces for space maintenance is that additional anchorage is available to support active tooth movement which may be necessary at a later stage of treatment.

Distal movement

Upper molars

The indications for distal movement of the upper molars are as follows:

1. To create space for the relief of mild crowding

or the reduction of a slightly increased overjet. When small amounts of space are required, for example half a unit of molar correction, distal movement may be more appropriate than the extraction of premolar teeth.

2. To regain space which has been lost. Following unplanned loss of deciduous teeth space is often lost as the upper molar teeth rotate forwards into the extraction space. This will result in crowding of permanent teeth, commonly the second premolars.
3. Where premolar extractions will not provide sufficient space for relief of crowding or overjet correction, distal movement of the upper molars to obtain a Class I molar relationship may be required. It is important to remember that for effective distal movement the force directed to the facebow should be in the upper range and the patient must wear the appliance a minimum of 14 hours a day.

Because the buccal segments are divergent, as the molars are moved distally the inter molar distance needs to be increased to prevent a crossbite occurring. Expansion of the inner arm of the facebow will be necessary. This can be achieved by expanding the inner bow across the molar tubes. For distal movement, 2–5 mm of expansion each side is usually sufficient. If the upper molars are in palatal crossbite a greater amount of expansion – 10 mm – is indicated. Although crossbites can be corrected using extra-oral traction there are more efficient methods (Chapter 14).

In the upper arch, if the third molars are in a satisfactory position to erupt in a downward and forward direction the removal of the second molars can be considered. This has been shown to make distal movement of first molars easier to achieve.

Unilateral distal movement

Unilateral distal movement is not easily obtained using extra-oral force alone. If such movement is necessary, an alternative method utilizing a removable appliance supplemented with extra-oral traction is to be recommended. The molar teeth should be banded and extra-oral traction applied by means of a facebow and headgear. A removable appliance is fitted in addition, with a palatal cantilever spring on the molar requiring distal movement. The spring should be constructed of 0.7 mm diameter stainless steel wire. Retention is gained from the premolars and incisors. The removable appliance should be worn full time (Figure 9.10).

Molar rotation

It is not uncommon to find that following early loss of deciduous teeth the upper molars rotate forwards around their palatal roots. In order to regain space the molars will have to be moved distally and derotated. Severe rotations may necessitate banding the molars with the buccal tube on the distal aspect and subsequently repositioning the band when rotational correction has taken place (Figure 9.11).

Mild rotations can be corrected at the same time as distal movement by adjustments to the facebow. The inner arm of the facebow is 1.15 mm diameter. Minor alterations to the distal

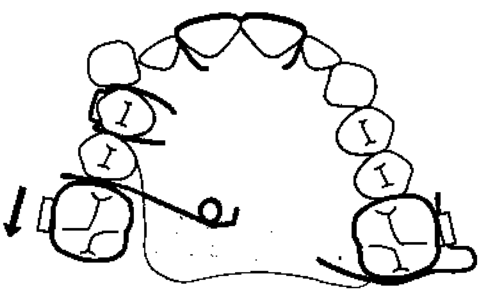

Figure 9.10 An upper removable appliance to provide unilateral distal movement. Extra-oral traction is applied to bands on first molars

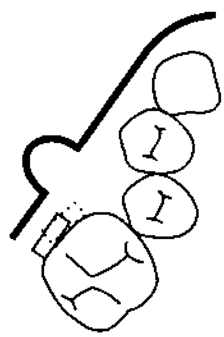

Figure 9.11 When a molar is rotated it may be necessary to position the buccal tube at an offset in order to insert the facebow. Once the molar has been corrected the band should be repositioned (shown by the dotted line)

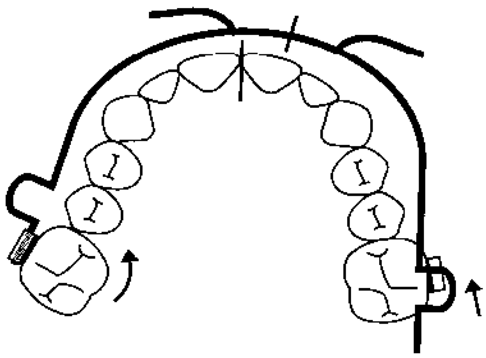

Figure 9.12 Engaging the facebow will derotate the opposite molar

end of the bow will produce significant forces on the molar teeth. Adjustment of the inner arch is made so that it lies at a slight angle to the molar tube. When inserted into the molar to be rotated the stop on the opposite side should lie distal to the molar. This will produce a rotational force (Figure 9.12). As soon as the molar rotation is corrected the molar band should be repositioned and the facebow readjusted to apply a direct distal force.

Orthopaedic effect

In order to restrict the downward and forward growth of the mid face forces will need to be transmitted to the sutures of the maxilla. In a similar manner to distal movement of molar teeth the ideal force should pass through the centre of resistance of the body to be moved. The centre of resistance of the maxilla is difficult to identify, but it may be presumed to lie above the apices of the premolar teeth. It is not particularly easy to direct a backward and upward force through this point as forces applied to the maxilla will also have an effect upon the teeth.

In order to restrict maxillary development, forces will need to be greater than those utilized for tooth movement. Proffit suggests a magnitude of force of 350–450 grams each side with a duration of force of 12–14 hours a day. If extra-oral forces are applied to the molar teeth tooth movement will occur with a rotational effect upon the maxilla. A more effective method of restraining maxillary growth would be to ensure the forces are applied to the entire upper arch. This can be achieved with the use of a removable appliance which incorporates acrylic covering of the upper teeth. The facebow is usually permanently attached to the appliance by means of tubes incorporated within the acrylic.

Orthopaedic effects from extra-oral forces are unpredictable and are probably best carried out in the pre-adolescent patient.

Practical management

It is mandatory that safety designs of headgear are used at all times. When the facebow and headgear are first fitted the patient should be instructed in its placement and removal. Once the patient can manage to assemble the appliance it should then, where appropriate, be demonstrated to a parent. Motivation can be maintained if the patient is provided with a 'time sheet' which should be completed each day recording the hours the headgear has been worn. At each visit the patient should bring the headgear and the time sheet in order that they may be checked by the orthodontist. Any necessary adjustments should then be carried out. The patient should be asked to fit the headgear, and observed to ensure that they are familiar with its insertion. Any difficulty in the fitting may be a sign of poor co-operation.

The headcap should be examined to ensure that it is intact and not causing discomfort. The outer bow of the facebow must not impinge against the cheek. The inner bow should be adjusted vertically and horizontally to ensure that the anterior section of the bow rests comfortably between the lips and does not contact the upper incisors when the headgear is in place.

The length of the inner bow should be adjusted to ensure that it does not contact any teeth apart from the molars. This is particularly important if the molar teeth are being moved distally as the inner bow will come closer to the incisors. Adjustment is carried out by opening the 'U' loops. The inner bow may also need to be expanded to prevent the molars moving into crossbite as they move distally.

Any loose or damaged parts should be replaced. A record of any observations, adjustments and checks on the safety of the appliance should be made in the notes.

The occlusion should be compared with the reference models to ensure satisfactory tooth movement is taking place.

Protraction headgear

The majority of headgear wear is used to reinforce posterior anchorage or to achieve distal movement. However, there are occasions when an anterior component of force is required. Class III cases may benefit from forward traction in the upper arch. Space closure in hypodontia cases can be assisted by bringing posterior teeth forwards. In such cases protraction headgear can be used (Plate 16). Although commercially made protraction headgears are available many operators prefer to construct a prescription appliance for each patient. Whatever variety is used protraction headgear consist of a wire frame connected to chin and forehead pads. Hooks are used for the attachment of latex elastics which are engaged onto the archwire. This form of traction is only advised for tooth movement, as there is to date no firm evidence to show that protraction headgear will have any significant orthopaedic effect.

Patient motivation

It has been stressed in this chapter that headgear wear requires a high degree of co-operation on the part of the patient. It is the orthodontist's responsibility to encourage confidence in the use of the appliance and to motivate the patient.

When extra-oral anchorage is to be used it is best to fit the headgear at the commencement of treatment. It is usually difficult to increase a patient's motivation part way through treatment, and introducing headgear at this stage is rarely successful. When it is clear that intra-oral anchorage will be sufficient the headgear can be dispensed with.

Motivation can often be maintained with the use of charts which the patient completes to record the time the appliance is worn each day. The regular checking of these charts will make the patient aware of the need to maintain the correct amount of wear. When it is apparent that a patient is not co-operating sufficiently with extra-oral wear it is best to challenge them with a direct question, such as 'Why are you unable to wear your headgear sufficiently?'. This makes it difficult for the unco-operative patient to disguise their non-compliance.

Warnings and safety

Cases of severe soft tissue injury to the face, eyes and mouth have been reported as a result of accidental displacement of the facebow. Both the patient and parent must be advised that great care must be taken when wearing the headgear. It is generally advisable to recommend wear only out of school hours, while at home and in bed at night. Warnings must be given about avoiding rough and tumble with friends and other children. The use of a safety mechanism designed to prevent injury from the facebow is mandatory and the importance of wearing this safety mechanism as instructed at all times when the headgear is worn must be stressed. If on any occasion the headgear bow becomes displaced when the patient is asleep, then headgear wear should be discontinued, and an appointment made as soon as possible.

Various designs of the ends of the inner bow have been produced including a doubling back of the wire so that the free end is not exposed, but this may make the inner bow more difficult to fit. Designs incorporating plastic covers which protect the ends are also available. The hook on the outer arm can be constructed in such a way that the free end is not exposed.

A variety of mechanisms are available which release the tension when an excessive force is placed on the facebow. These 'snap-away' traction appliances (Plate 15) are designed to avoid 'catapult' injuries, but they do not prevent the injury to the patient which may follow if the facebow becomes inadvertently displaced from the mouth during sleep, and the patient turns their head in such a manner that one of the ends of the facebow causes a penetrating injury.

Restraining safety straps which physically prevent inadvertent removal of the facebow from the mouth are the preferred safety method. They have to be fitted by the patient when the headgear is assembled. Used in conjunction with appropriate facebow design they offer the maximum protection (Plate 13).

Specific verbal and written instructions should be given to patients wearing extra-oral appliances. In the case of minors, parents should also be informed:

- Hold the bow in the mouth while the traction force is engaged or disengaged.
- Immediately hold and restrain the bow if it becomes loose.

- No vigorous activity when wearing the headgear.
- Report any damage or breakage of the appliance as soon as possible.
- Never wear the headgear without the safety device being in place.
- Stop wearing the headgear, and contact the orthodontist if the bow comes out at night.

An example of written instructions is given in Appendix 2.

Reference

Proffit, W. (1993). *Contemporary Orthodontics*. 2nd edn, Mosby, St Louis.

Further reading

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10

Initial alignment

This first stage of tooth movement is primarily concerned with the correction of gross individual tooth displacements. Before proceeding to select the initial archwire, the operator must stop and think of the consequences of fitting this first active component.

If anchorage needs reinforcement then the extra-oral appliance should be fitted at the outset of treatment rather than being added after tooth alignment has begun. The initial stages of tooth alignment often place heavy demands on the available anchorage and this needs careful monitoring. In addition, a patient's co-operation is usually greatest at the commencement of treatment and an attempt to introduce headgear to a patient well into treatment is rarely successful.

It is also important for the operator to be aware of what tooth movements are needed in this early stage of treatment. The treatment plan should have been finalized by this stage but it will need translating into an 'orthodontic mechanics treatment plan'. What are the planned steps required in getting to the finished result? The first aim clearly is to get all the teeth, with the exception of isolated grossly displaced teeth, fully engaged onto the archwire. It is only when that stage has been reached that is it advisable to continue with other tooth movements such as canine retraction and overjet correction. A sound understanding of the planning of these mechanical procedures is essential for the beginner to orthodontics – only when a step by step mechanical plan has been formulated will the orthodontist have a clear route to follow to the treatment goals.

Initial alignment is the first stage of any orthodontic treatment with fixed appliances and will involve bracket levelling and other tooth movements such as uprighting, rotational correction and the correction of labiolingual displacements of individual teeth. These will be discussed in turn. For sake of clarity the different types of tooth movements have been described individually, but clinically many of them will be occurring simultaneously.

Bracket levelling

The levelling of the bracket heights is carried out as one of the first stages of treatment. It must not be confused with the reduction of an increased overbite. Overbite management will be covered in Chapter 12.

Bracket levelling will commence as the flatness of the archwire in the horizontal plane is expressed. It is important to check that the archwire is flat before it is inserted in the mouth. An understanding of bracket levelling will immediately confirm the importance of placing the brackets at the correct height on the crowns of the teeth. Any errors introduced at the bracket placement stage will become obvious as bracket levelling proceeds. Should this be the case it is advisable to reposition the bracket at its correct height before the completion of the bracket levelling stage.

Bracket levelling is commenced with light round archwires, for example 0.015 in multistrand or 0.012 in nickel-titanium. Any teeth which cannot be fully engaged on the archwire may be loosely ligated to it using a steel ligature. If a tooth is severely displaced the best approach is first to achieve full bracket engagement of the remaining teeth. As soon as a stainless steel archwire of at least 0.018 in diameter is in place the displaced tooth can be moved towards this rigid base archwire by attaching it with elastic chain or thread. When the displaced tooth has moved closer to its correct position in the arch, it may be practical to revert to a flexible archwire which can be fully engaged in the bracket. Only when full bracket levelling has been achieved is it possible to proceed to thicker archwires to enable other tooth movements to be carried out.

It is worth repeating that an important rule of this initial phase of treatment is not to proceed to the next archwire until full bracket engagement has been achieved. If a multistrand archwire has been used then it is advisable to renew it at each visit. An advantage of the nickel-titanium archwires is their ability to withstand permanent deformation and it is not always necessary to remove such archwires fully from the mouth but merely to reactivate them by retying those teeth not fully engaged on the archwire. However, for the newcomer to orthodontics it is advised that the archwires are removed at each visit and the wire and attachments checked.

Initial tooth alignment

The tooth movements discussed above deal only with the levelling of bracket heights in the vertical dimension. Bracket alignment covers such tooth movements as uprighting, rotational correction and labiolingual movement. Before describing how such movements are undertaken it is important to re-emphasize the maintenance of arch form and lower incisor labiolingual position. Unless adequate care is taken to match the archwire to the initial arch form it is easy to alter the arch dimensions by expanding the intercanine width.

Centre-line discrepancies

It is pertinent to discuss centre-lines here because it is advisable to correct the dental centre-lines early in treatment, if at all possible. Centre-line correction can often prove difficult and at this early stage in treatment it would be good planning to have a clear idea of how this problem may be dealt with. **Once again the advice is to plan ahead.**

Occasionally, where there is a discrepancy of a centre-line the anterior teeth may be tipped towards the affected side. During the initial stages of treatment these tipped teeth will tend to upright thereby correcting the centre-line as long as space is available.

The angulation of the canine teeth will also have an effect upon the centre-lines. A distally inclined canine will tend to upright by mesial movement of its crown. This may be restricted by tying the canine tooth back to the first molar in the same quadrant. Selected use of such 'lace backs' on one side but not the other may also assist in centre-line correction.

A centre-line discrepancy associated with bodily tooth displacements rather than with tipped teeth is more difficult to correct. It is rarely possible to treat such problems in the initial alignment stage. More often, a centre-line discrepancy is treated once initial alignment is completed and a working archwire has been fitted. It may then be possible to correct the centre-line by using a number of methods, for example asymmetrical elastics, class II intermaxillary elastic on one side and class III elastics on the other side. An alternative method is to use an anterior intermaxillary cross elastic. Centre-line correction, especially where there is a considerable discrepancy, can be difficult to correct.

Labiolingual displacements

If there is inadequate space for the alignment of the teeth in the labial segment then engaging all teeth on the archwire during the early stages will move the teeth onto the arc of a larger circle so moving the incisors in a labial direction (Figure 10.1(a) and (b)).

This may be an acceptable part of the treatment plan, for example when it is necessary to procline the upper incisors to correct a Class III incisor relationship. However, it is more often the case that this is an unwanted tooth movement, particularly in the lower arch. It is advised that space should be provided for the alignment of the incisors by retraction of the canines before proceeding to align the incisors (Figure 10.1(c)

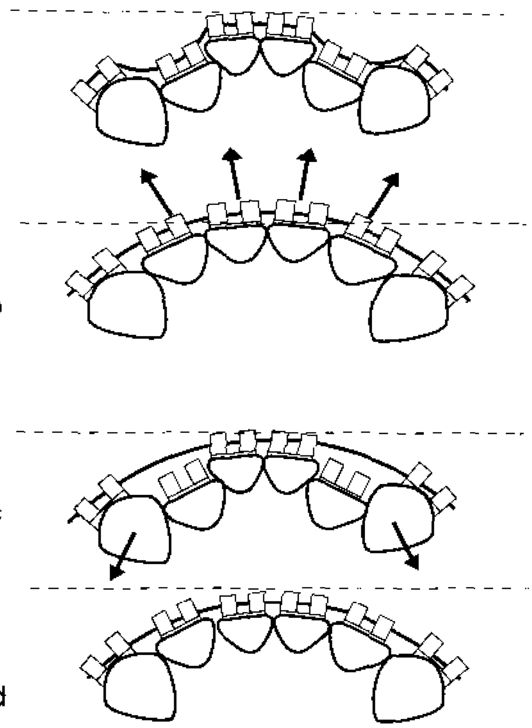


Figure 10.1 Initial lower incisor alignment: (a) engagement of the archwire in all the brackets when space is not available will result in (b) incisor proclination. Retraction of the canines (c) will allow labial segment alignment with minimal proclination

and (d)). It is wise not to attach the incisors to the appliance in the initial stages of general tooth alignment where crowding in the lower labial segment is present. Indeed this illustrates the principle of not attempting to align a tooth that has inadequate space for alignment. The practical point is that unless the canines are retracted first space will not be available to align the lower incisors. The consequence of fully engaging the archwire before adequate canine retraction will result in unwanted proclination of the lower labial segment.

Uprighting

Uprighting movements are more readily achieved with a wide bracket such as a Siamese edgewise bracket and are again best undertaken using light archwires.

Teeth will tend to move in the direction of least resistance. If the crown of the tooth is already in the correct position but apical movement is required, the crown must be prevented from undergoing movement by ligating it to the adjacent teeth. Failure to do this may result in a space opening adjacent to the uprighted tooth.

The situation often arises when uprighting canine teeth. Preadjusted edgewise systems have a degree of tip built into the canine brackets. Unless the canines are already mesially inclined, these teeth will tip mesially during the early stages of tooth alignment. Such uprighting will occur much more readily by mesial movement of the crowns of the teeth than by the more desirable distal movement of the root apices. These movements will lead to an increase of the crowding in the labial segments and encourage the forward movement of the teeth in the buccal segments. Unwanted mesial movement of the canines may be restricted by tying back the canines to the first, and if possible second, molar teeth. The use of such ligatures on one side of the arch only may be of assistance in centre-line correction. These lace backs should not be tightened excessively as they are merely to act as a restraint to the forward movement of the canine crowns. Lace backs will also need to be considered with a plain edgewise system if the canines are distally inclined (Figure 10.2).

It is important to remember that the anchorage which restrains forward movement of the canines is provided primarily by the first molars and that if the space available is critical then the forward movement of these teeth should be controlled with either a lingual arch or extra-oral forces.

As previously discussed, preadjusted canine brackets have a degree of tip built into them. If the canine is distally inclined then the archwire which emerges from the mesial aspect of the bracket will lie incisal to the incisor brackets (Figure 10.3). If this wire is now engaged into the incisor brackets it will tend to extrude these teeth and so cause an increase in the overbite.

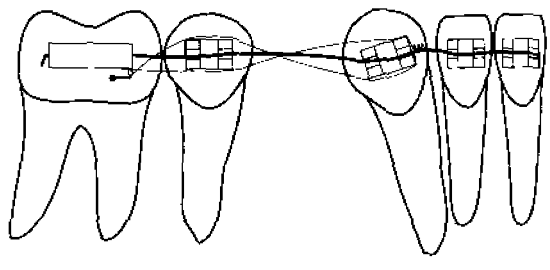


Figure 10.2 The distally inclined canine is 'laced back' to prevent mesial movement of the crown during uprighting

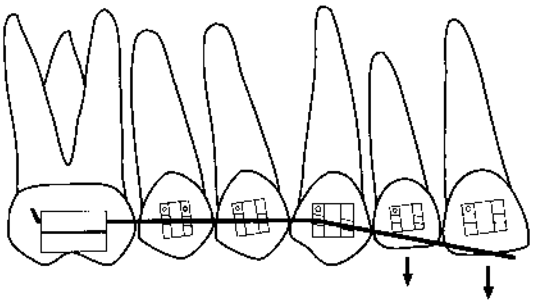


Figure 10.3 The tip in the preadjusted canine bracket will tend to produce an extrusion of the incisor teeth and so deepen the overbite

This increase in overbite during the levelling and alignment stage is a well-recognized complication of treatment with a preadjusted edgewise appliance. Such an increase in overbite is rarely desirable and can be avoided by not engaging the incisor teeth until the canines have uprighted. The effect of the canine bracket tip on the overbite may be reduced by not using too stiff an archwire in the early stages of treatment and by allowing sufficient time for the canine to upright itself before moving up to a stiffer archwire.

Rotational correction

As with other types of displacements, it is not advisable to attempt the correction of rotations until there is adequate space. Any attempt to squeeze the tooth into alignment will result in an unfavourable movement of adjacent teeth as shown in Figure 10.1. It is therefore important to create adequate space for the alignment of the teeth before attempting to tie the tooth to the archwire. This will probably mean retracting the canines along a stiff wire, before returning to lighter wires for rotational correction. Once adequate space has been made then rotational correction is relatively easily achieved with a fixed appliance if a wide bracket is used. It is important to use an archwire of sufficient flexibility to engage the bracket slot.

Bracket ligation

Archwires can be ligated to edgewise brackets by using a steel ligature or an elastomeric ring. If the archwire lies passively within the bracket slot then the ligature will merely serve to hold it in position. However, if the archwire does not lie fully engaged within the bracket, then the ligature must be tied tight enough to activate the archwire towards full engagement.

If a steel ligature is used it is often advisable, unless a loose tie is required, to use ligature locking pliers which allow the ligature to be tightly ligated around the bracket. These instruments are difficult to use at first but do allow the archwire to be firmly seated into the bracket slot. If an elastomeric bracket module is used then it is advisable to use a figure-of-eight ligature which will tie the archwire tightly into the bracket slot (Plate 17).

If a steel ligature is used then consideration can be given to using a 'rotation tie'. In this situation the ligature wire passes underneath the archwire on the side of the tooth which needs to move away from the archwire but is tied tightly over the archwire on the side of the tooth which needs to move with the archwire. It is also possible to use a rotation wedge to push the tooth away from the archwire where this is required. These are only appropriate with rigid archwires and are often used to effect rotational overcorrection. Rotation wedges are quite bulky and do interfere with the oral hygiene close to the bracket.

The correction of premolar rotations may be undertaken in a similar manner to that described above. However, it is also possible to use attachments bonded on to the palatal aspect of these teeth to help produce a rotational couple. These attachments may either be directly bonded to the tooth surface or welded on to the premolar band. Rotational correction can then be undertaken by attaching an elastic ligature from the lingual cleat or button and running it to the archwire or to a similar attachment on an adjacent tooth (Figure 10.4). If the elastic is attached to an archwire, the wire must be of sufficient rigidity to resist distortion and a diameter of at least 0.016 in is recommended.

The anchorage required to effect the rotations is provided by the first molar tooth in Figure 10.4(a) and all the teeth in the buccal segment in Figure 10.4(b). To prevent unwanted tooth movements the following adjustments may need to be made to the archwires: an antirotational bend, or toe-out, for the first molar in (a) and some buccal expansion of the archwire in (b).

For the correction of rotational displacements it is best not to dispense with light archwires until rotations have been fully corrected. It is the full engagement of a flexible wire into the bracket

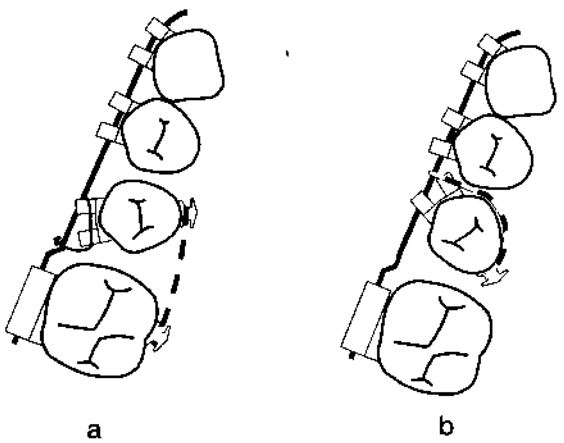


Figure 10.4 Correction of premolar rotations: (a) using elastic chain or thread to a cleat on the molar; (b) using elastic chain or thread direct to the archwire

slot which will correct the rotation. A stiffer wire will not be able to be fully engaged in a rotated bracket and the full potential of the archwire cannot be expressed. Only the lightest force needed to move the tooth should be employed.

Initial alignment using Begg brackets

The Begg bracket has a minimal mesiodistal width and the archwire is a loose fit in the bracket channel. The system facilitates rapid initial alignment because there is minimal friction between the archwire and bracket and the teeth are free to tip into alignment. However, because of the design of the bracket, apical movements such as uprighting and torqueing are not possible without the use of auxiliary springs. These cannot be used until a later stage of treatment is reached and rigid base archwires have been fitted.

Summary

The initial phase of fixed appliance orthodontic treatment is concerned with bracket levelling and with the alignment of individual teeth. It is possible to undertake rotational correction, labiolingual correction and uprighting movements at the same time. This complex combination of tooth movements means that a careful monitoring of tooth position and the available anchorage must be made at each visit.

A number of guidelines are suggested for the levelling and alignment stage of treatment:

1. **Do** use the lightest possible forces to produce the required tooth movement.
2. **Do** allow sufficient time for the uprighting of teeth, especially the canines.
3. **Do**, above all, be patient.
4. **Do not** move up to the next archwire size until full bracket engagement has been achieved with the present archwire.
5. **Do not** leave the initial wires and proceed to the working wires until sufficient rotational correction has been achieved.
6. **Do not** attempt to align a tooth unless there is adequate space available for it.
7. **Do not** use intra- or intermaxillary traction in this stage of treatment. The initial archwires are insufficiently rigid to prevent the unwanted movement of anchorage teeth.

At the end of the initial alignment stage it is advisable to remove the archwires and check the **position** of all bands and brackets. Incorrect bracket positions are more clearly seen at this stage and it is best to reposition them before progressing to the next stage of treatment.

Further reading

McLaughlin, R. P. and Bennett, J. C. (1989). The transition from standard edgewise to preadjusted appliance systems. *Journal of Clinical Orthodontics*, **23**, 142–53.

Robinson, S. N. (1989). Evaluation of the changes in lower incisor position during the initial stages of clinical treatment using a preadjusted edgewise appliance. M.Sc. thesis, University of London.

11

Canine management

The management of canine displacement merits separate consideration for two reasons. Firstly, in order to emphasize the importance of correct positioning of the permanent canines – which is essential if the maximum advantages of treatment are to be realized for the occlusion as a whole. Secondly, to focus attention on the mechanical and anchorage aspects of canine alignment. Permanent canines are often crowded, and may be markedly displaced. As a consequence of their relatively large roots, correction of canine position can be particularly demanding in terms of appliance mechanics and anchorage management.

The permanent maxillary canine has a long path of eruption. Its eruption may be delayed or prevented as a consequence of severe developmental displacement.

In crowded arches, the permanent canine crowns are commonly prevented from erupting into good alignment with neighbouring teeth, and may become displaced buccally or sometimes lingually. Marked angular, vertical, mesiodistal and rotational displacements are also seen.

Canine position

The position of the canines is a matter of great importance for aesthetics and for stability of the treated occlusion. One of the fundamental considerations at the treatment planning stage is the positioning of the canines.

It is an important principle to begin the planning process by considering the lower arch. If, as is often the case, the lower incisors and canines are unacceptably crowded a decision must be made as to how space is to be obtained.

As a general rule, it is inadvisable to obtain space for incisor alignment by moving the lower incisor crowns labially. The danger is of placing them in a position of soft tissue instability, from which they will soon relapse following removal of the appliance, with recurrence of crowding and a change in the relationship between upper and lower incisors.

In most cases it is advisable to obtain space for incisor alignment by moving the lower canines distally. This will often indicate the need for extractions distal to the canines. Two questions present themselves at this stage:

1. How far must the lower canines be moved distally? The simple answer to this question is: 'Far enough to allow alignment of the incisors without needing to move the incisor crowns labially'. In practice, it is unusual for the canine displacement to be identical on both sides of the arch. It is probable that one of the canines will require more distal movement than the other – and this will be an important consideration in cases requiring correction of the centre-line.
2. Where should the lower canine crowns be placed buccolingually? As a general rule, expansion or contraction of the lower intercanine width is unlikely to remain stable after removal of the appliance. Of course, when the canine crowns are severely displaced either buccally or lingually, then change in the

intercanine width is inevitable. When the developmental form of the lower arch is narrow anteriorly, and exhibits considerable divergence distally, expansion of the intercanine width is necessary if the canines need to be moved distally by an appreciable amount. It should be remembered, however, that there is a tendency for progressive decrease in intercanine width and increase in lower incisor crowding throughout adult life.

Only when the planned position of the lower canines has been determined can decisions be taken about positioning the upper canines. If a Class I incisor relationship at the completion of treatment is the aim, the upper canines will need to be moved into Class I relationship with the final position of the lower canines. This approach focuses attention on the importance of correct canine position and assists treatment planning in both arches.

In the majority of cases the aim will be for a Class I canine relationship. The role of the canines in the functional aspects of occlusion will also need to be borne in mind. It is considered desirable where possible to complete treatment with a 'canine guided occlusion' in which, on lateral mandibular excursion, there is intercanine contact with disclusion of the other teeth. This aim indicates the need for adjustment of the buccolingual, vertical and angular positioning of the canines, bearing in mind that either increasing or decreasing the intercanine width may lead to instability.

When the anticipated position of the canines at the end of treatment has been identified, appliance mechanics and anchorage management can be planned.

The mechanics required are dependent upon the initial position and displacement of the canine. The operator must consider the mesiodistal, rotational, vertical and angular aspects of the canine position before appliance design can be formulated. The anchorage demands associated with relocation of the canines can then be estimated. If, for instance, they need to be moved distally, and are already distally inclined, then anchorage demands are much greater than if they are mesially inclined (Figure 11.1).

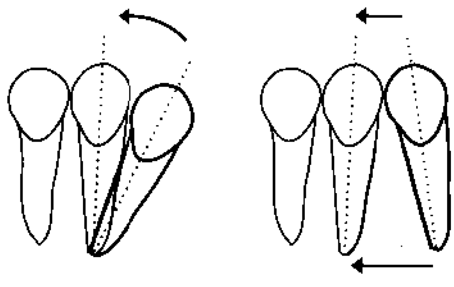


Figure 11.1 Anchorage demand for distal movement of a mesially inclined canine: (a) is considerably less than if the canine is distally inclined, (b)

Spontaneous tooth movement

When crowding is present, extractions will often provide space for spontaneous improvement in canine and incisor position. This is particularly the case when:

- space is provided adjacent to the canine, usually by extracting a first premolar;
- the canine has commenced eruption and is still actively moving towards the occlusal plane;
- the angulation of the canine is favourable – for instance when the canine is mesially inclined it can be expected to become more upright as the crown moves towards the space created by extraction of a first premolar.

Taking advantage of spontaneous favourable tooth movement means a reduction in the time appliances must be in place, and less demand placed upon anchorage. Significant spontaneous improvement may continue for approximately three to six months following extractions, so in some cases it is advantageous to delay the application of forces to improve canine position until after this period of time has elapsed.

However, there is a potential risk to delaying the fitting of appliances while waiting for spontaneous improvement. Although first premolar extraction will provide space for an improvement in canine position, it will also allow forward movement of teeth distal to the extraction site. In some cases this mesial movement is quite acceptable.

On the other hand, where all the extraction space is needed for alignment of teeth mesial to the extraction space, or when anchorage demands are considerable, steps must be taken to prevent mesial drift of premolars and molars. In this situation, a removable appliance clasping the first molars, or a palatal or lingual arch soldered to first molar bands can be used as a space maintainer. Extra-oral anchorage applied

to upper molar bands can be used either alone or together with the removable appliance as an additional means of preventing unwanted mesial movement of molars.

When the space available is critical it is wise to fit the space maintainer before extractions are carried out.

Having outlined the general principles of canine management the chapter will continue by considering the appliance mechanics and anchorage aspects of dealing with specific canine displacements.

Canine alignment using removable appliances

A limiting factor with removable appliances is their inability to correct canine rotations and apical displacements. In the case of severely displaced teeth there is difficulty in finding a point of application for removable appliance springs. Even if it is possible to find a point of application it is unusual to be able to apply force in an ideal direction. Severely displaced canine crowns will usually need to be moved occlusally and extrusive forces are impossible to apply to canine crowns using removable appliances alone.

Nevertheless, it is possible to achieve substantial improvement in canine position using a removable appliance when the crown is accessible and when tipping of the canine is appropriate. Canine alignment may be commenced using a removable appliance and completed using a fixed appliance.

A removable appliance can be useful in the upper arch when the canines are mesially inclined, need to be moved distally and are fully, or nearly fully, erupted. Either palatal or buccal springs are used, according to the position of the canine. The canine crown can be moved distally and palatally if necessary, but the tooth will tip, with the crown moving in the direction of the force applied and the apex moving in the opposite direction. The removable appliance, with application of light forces producing tipping movements, will minimize the strain placed upon intra-oral anchorage. It can incorporate an anterior bite plane to begin overbite reduction and provide clearance for the attachment of brackets to lower incisors and canines.

Removable appliances should only be used in this way to commence distal movement and uprighting of mesially inclined canines. Retraction must not be allowed to continue until the canine becomes distally inclined.

It may be decided to begin treatment by using an upper removable appliance incorporating canine retraction springs and an anterior bite platform as described above. The aim of the removable appliance stage is to begin canine retraction and overbite reduction, completion of treatment being achieved using upper and lower fixed appliances. The lower fixed appliance must be in place before the upper removable appliance is discarded, or the overbite reduction which has been achieved will be lost. When the upper fixed appliance is fitted the canines must be ligated back to the molars in order to prevent them relapsing towards their pre-retraction positions.

A removable appliance and a fixed attachment combination can provide a useful method of moving a buccally placed and partially erupted canine in an occlusal direction (Plate 18). A long flexible buccal arm is used to engage an attachment bonded to the buccal surface of the canine. Alternatively, the patient can be instructed in the application of a latex elastic ring between the canine attachment and a suitably located hook on the removable appliance.

The clasps and baseplate of the removable appliance provide access to excellent vertical anchorage for the occlusal movement of the canine.

Occasionally an upper removable appliance can be useful in the early stages of correction of a severely displaced palatal canine.

Canine alignment using edgewise brackets

Initial alignment

The reader is referred to Chapter 10 for a full discussion of the tooth movements and archwires used in the initial alignment stage. The first objective is to gain full engagement of the archwire in the bracket channels, using archwires of appropriate stiffness, range and strength. This process will commence the correction of vertical, rotational and angular displacement of the canines, and the overall archwire form will influence the buccolingual position of the canine crowns. Mesiodistal movement of the canines must be delayed until the more rigid archwires of mid-treatment are in place.

The resistance to movement offered by large canine roots has an important bearing on the

effects of archwires used in the initial alignment stages. Compared to the incisors, particularly the lower incisors, canines offer relatively high resistance to movement and move slowly. If an initial archwire of low stiffness, for example nickel-titanium, is attached to all the brackets in a lower arch which has a crowded labial segment, the lower incisor crowns will be moved labially. This will happen even if space is available distal to the lower canines because the incisors offer little resistance to proclination.

The likelihood of this lower incisor movement must be remembered, and corrected at a later stage following distal movement of the canines. It is, however, difficult to identify the stable labiolingual position of the lower incisor crowns once they have been moved from their pre-treatment position.

The treatment sequence described above involves proclination of the lower incisors which must be corrected later. A safer approach, and one which is particularly appropriate for those less experienced in the use of fixed appliances, is to postpone incisor alignment until the canines have been moved distally. If this approach is taken, canine retraction is achieved either by using sectional archwires or by using a continuous archwire which is not attached to the lower incisors. Brackets will not need to be fitted to the lower incisors until the canines have been moved distally and sufficient space is available to achieve incisor alignment without proclination.

Lower arch treatment is commenced with initial alignment archwires of low stiffness attached to the canine, premolar and molar brackets. When a mid-treatment working archwire is in place canine retraction is achieved using elastic thread or elastic rings. After canine retraction, the lower incisor brackets are fitted. The archwire is exchanged for one of low stiffness again, and the lower incisor brackets attached to the archwire. At this stage the lower canines must be ligated back to the molar hooks to prevent them relapsing forwards.

The same possibility of labial movement of incisor crowns applies in the upper arch. However, it is the position of the **lower** incisors which is such a valuable guide to incisor stability at the end of treatment.

Labial movement of the upper incisor crowns during the initial stages of canine alignment is of less importance because it is the stable position of the **lower** incisors which determines the position of the upper incisors at the end of treatment (assuming that the aim is a Class I incisor relationship).

In Class III cases labial movement of the upper incisors may be needed for correcting the incisor relationship.

Canine angulation

When the canine is mesially inclined, a flexible archwire will apply a force couple to the canine bracket (Figure 11.2). This couple will tend to move the canine crown distally, although this movement will be impeded by friction between the archwire and the bracket channel. The couple will also tend to move the apex mesially – but this movement will occur only slowly, and in practice change in angulation will occur mainly by distal movement of the crown.

When the canine is distally inclined, and particularly when preadjusted brackets are in use, the initial archwire of low stiffness will apply a force couple tending to move the canine crown mesially and the apex distally (Figure 11.3). If, as is usually the case, the eventual requirement

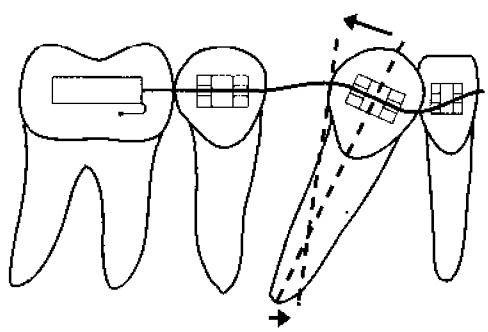


Figure 11.2 A flexible archwire will apply a force couple to a mesially inclined canine tending to move the crown distally and the apex mesially

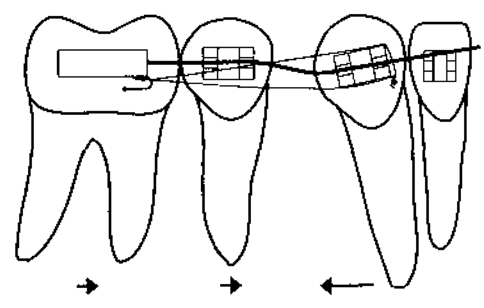


Figure 11.3 A flexible archwire will apply a force couple to a distally inclined canine tending to move the crown mesially and the apex distally. A tie ligature is used to prevent mesial movement of the canine crown

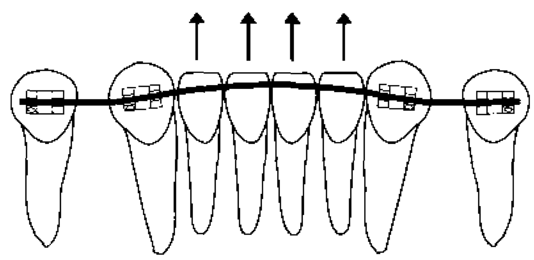


Figure 11.4 An initial aligning archwire engaging distally inclined canines may cause an increase in overbite (incisor brackets omitted for clarity)

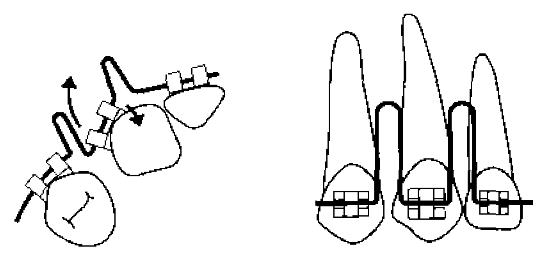


Figure 11.5 Vertical loops on either side of a rotated canine to provide flexibility for derotation

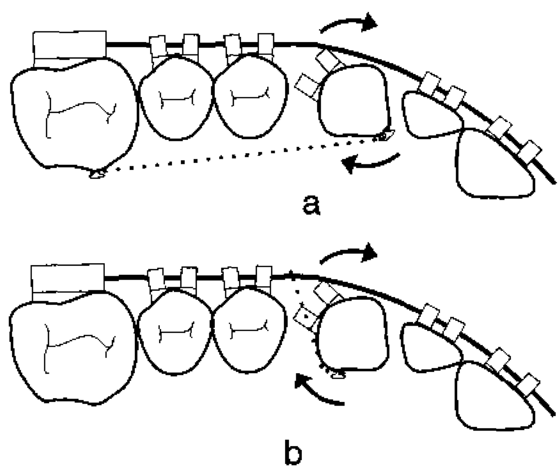


Figure 11.6 A button or cleat on the palatal aspect of a rotated tooth can provide a point of attachment for an elastic ligature. The elastic may be tied (a) to another tooth, or (b) to the archwire. In either case the archwire form will need to be adjusted to minimize the unwanted tooth movement which would otherwise arise from the reciprocal force

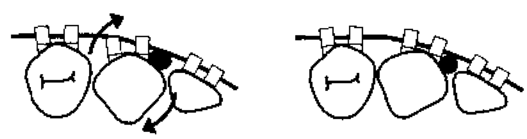


Figure 11.7 When an archwire of high stiffness is in use, a rotation wedge can be used to achieve minor rotational correction

is to move the crown distally, the canine bracket must be tied back to the molar hook in order to promote change in angulation by distal movement of the canine apex. Tying back the canine crown in this manner is continued while archwires of increasing stiffness are fitted. The tie-back ligature can be placed before the archwire is inserted, and left in place during successive archwire changes, but it *will* be necessary to check the ligature for tightness at each visit.

When the canine is distally inclined the labial section of the archwire is displaced in an occlusal direction, and there is a possibility of unwanted extrusion of the incisors, with increase of overbite (Figure 11.4). This tendency will reduce as canine uprighting occurs, but when the distal inclination is marked it is advisable to leave the incisors unattached to the archwire, or to make compensating bends in the archwire mesial to the canines. An alternative approach is to use a sectional archwire initially. The anchorage required for uprighting a distally inclined canine is provided by the molar to which the canine is tied. Considering the amount of root movement required, anchorage reinforcement will usually be indicated.

The uprighting of distally inclined canines will occur slowly, and distal movement of the crown must be delayed until it is complete. Only when a mid-treatment archwire is in place and the distal inclination of the canine has been corrected, should active canine retraction be commenced.

Canine rotation

Mild to moderate canine rotations are corrected during the initial alignment stage. Vertical loops placed in the archwire may be used to facilitate rotation (Figure 11.5).

When the rotational displacement is severe, elastic thread, chain or latex elastic rings can be useful. Palatal or lingual attachments are positioned so that the elastic applies a rotation force. The use of elastic thread to rotate a canine is illustrated in Figure 11.6. The reciprocal force effects of the elastic must be anticipated and compensating bends may need to be placed in the archwire to prevent unfavourable movement of the teeth providing anchorage.

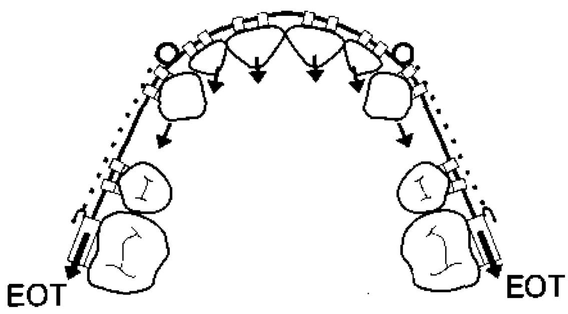


Figure 11.8 Elastic traction applied to archwire hooks to retract canines and reduce the overjet. EOT is used to control reciprocal forward movement of the molars and premolars

A rotation wedge (Figure 11.7) can be of assistance in producing minor rotational correction, particularly when mid-treatment archwires are in use.

Mesial and distal movement of canines

In order to achieve maximum benefit of the relationship between the archwire and the relatively wide edgewise brackets it is important to postpone mesial or distal movement of the canines until the brackets are fully engaged on an archwire of sufficient stiffness. By this stage vertical, rotational, angular and labiolingual canine displacements should have been largely corrected. The use of an archwire of sufficient stiffness is important because it enables effective control of both the canine and the teeth providing anchorage.

Mesial or distal movement of the canines can then be commenced, either by moving them:

1. *Together with the archwire*
   In this case, the canine bracket maintains a constant relationship with the archwire occupying the bracket channel. The canine moves together with the archwire and there are no frictional losses between the archwire and the canine bracket. The archwire may be passive as in Figure 11.8, where the retraction force is delivered by elastic traction. Alternatively, the archwire may be active as in Figure 11.12, which illustrates 'closing loop mechanics'.
2. *Along the archwire (sliding mechanics)*
   In this case the canine bracket slides along the archwire. An auxiliary – for example a elastic ring (Figure 11.9) or a coilspring (Figure 11.10) – is used to apply force to the canine. Some of the force applied is inevitably dissipated in overcoming friction as the canine bracket moves with respect to the archwire.

Canine movement together with the archwire

In Class II division 1 cases it is possible to reduce the overjet and retract the upper canines in a single treatment stage, having already uprighted the teeth and corrected rotations and

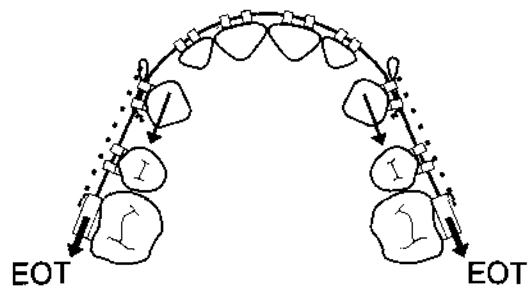


Figure 11.9 Canine retraction using sliding mechanics. Intramaxillary traction is applied using elastics between hooks attached to the canine brackets, and molar hooks

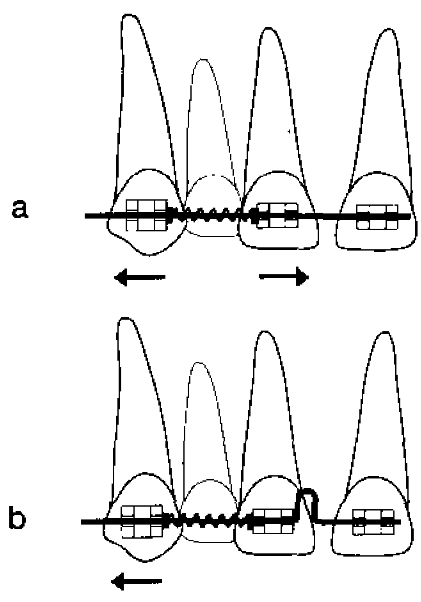


Figure 11.10 A compressed coilspring used to open space: (a) the canine will move distally and the central incisor mesially; (b) an archwire stop, placed against the mesial of the incisor bracket, prevents mesial movement of the incisor. The distal ends of the archwire must be turned up hard against the distal of the molar tubes

vertical discrepancies. A mid-treatment archwire is used, with all brackets fully engaged. The six anterior teeth are ligated together. Intermaxillary or intramaxillary traction is applied using latex elastic rings running between hooks mesial to the upper canines, and the molar hooks (Figure 11.8). Alternatively, a distal force can be applied to the archwire hook using a traction ligature or elastic chain (Plate 19). If round wire is used hooks are bent into the archwire mesial to the canines. When rectangular wire is used hooks are crimped or soldered to the archwire.

The brackets in the buccal segments must be well aligned in order to allow the archwire to slide distally. Preadjusted brackets are particularly convenient because they allow the use of a straight buccal archwire span, 'in out' activation being incorporated in the brackets. The mechanism illustrated in Figure 11.8 when used with the straight wire technique requires the archwire to slide distally through the premolar and molar attachments. Nevertheless, the incisor and canine brackets are moving together with the archwire.

As an alternative to using elastics, the archwire can incorporate a closing loop placed immediately distal to the canine bracket on each side. The closing loop is activated by pulling the buccal span of archwire distally and turning the distal end up behind the molar tube.

Considering the combined root surface areas of the canines and incisors, the force which will need to be applied and the resulting anchorage requirements will be large, particularly when rectangular archwire is used. Anchorage reinforcement using extra-oral traction will usually be necessary.

Canine movement along the archwire (sliding mechanics)

Sliding mechanics can be used for mesial or distal movement of canines with edgewise brackets. An archwire of at least 0.016 in round stainless steel must be used, and many operators prefer to use a more rigid wire – for example, rectangular stainless steel wire of 0.019 × 0.025 in. At least 0.003 in clearance between the archwire and the occluso-gingival dimension of the bracket channel is required for sliding mechanics. The archwire does not fit the archwire channel precisely, and the archwire may bend, so the canine will not move bodily. Nevertheless, free tipping is prevented and the anchorage demands are considerable. When the canines need to be moved an appreciable distance anchorage reinforcement may well be necessary.

There are a number of alternative methods for applying force to move the canine along the archwire.

Latex elastic rings can be used to move the canines distally (Figure 11.9). The elastic is attached to the canine using a modified stainless steel ligature which incorporates a hook (Kobayashi ligature). Alternatively the canine can be fitted with a bracket carrying a 'power arm' which enables the force to be applied nearer to the centre of resistance of the canine, improving the possibility of bodily movement and reducing bracket binding (Figure 11.11). Power arms make oral hygiene more difficult to maintain, and they may cause soft tissue trauma.

It is important that the canine ligature is sufficiently loose that it does not prevent movement of the canine bracket along the archwire. On the other hand, the ligature must restrict the mesiobuccal rotation which will tend to occur as the canine moves distally.

Elastic thread or elastic chain can be used in place of latex elastic rings. This approach avoids dependence upon the patient to change elastic rings, but it is impossible to maintain an accurately controlled and constant force application between appointments. The force applied by elastic thread or elastic chain reduces substantially in the mouth, and particular care must be taken to avoid the application of excessive force initially.

A retraction force of 70–90 grams is used on each side, the patient being instructed to replace the elastic rings every day, and immediately on breakage. It may be necessary to increase the force up to 150 grams when rigid rectangular archwires restrict tipping, but it is always advisable to use the lowest force required to produce movement. Avoidable and excessive

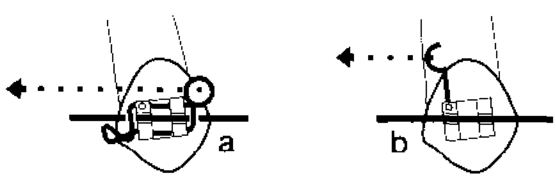


Figure 11.11 Methods of applying traction to a bracket: (a) a steel ligature incorporating a ring (Kobayashi ligature); (b) a bracket carrying a 'power arm'.

anchorage loss will occur when:

1. The ligature on the canine is too tight, preventing sliding along the archwire.
2. The retraction force is excessive. Remember that the canine will move more slowly than if it was free to tip. Patience is required, although measurable improvement in the canine position must still be expected at each visit.
3. There is obstruction to movement of the canine. This may be a problem when an upper canine comes into occlusal contact with the lower canine bracket or crown, and it can result in significant anchorage loss if it is not identified and corrected quickly. Temporary expansion of the upper intercanine width (or contraction of the lower), or removal of the lower canine bracket may solve the problem. Alternatively, canine intrusion using bite-opening mechanics (Chapter 12) can be used to move the canines out of occlusion.

A compressed coilspring can be used to move a canine along the archwire as in Figure 11.10, where space is being created for a crowded lateral incisor. The coilspring is threaded onto the archwire before bracket ligation and it will apply equal and opposite forces to the brackets against which it is compressed. The archwire must be sufficiently stiff – at least 0.018 in round stainless steel – to restrict tipping.

The effect of the coilspring will depend upon the resistance of the teeth to movement. It may be necessary to move only one of the teeth. For instance, the requirement may be to move the canine distally but to maintain the position of the central incisor. A 'stop' placed in the archwire mesial to the incisor bracket will prevent the incisor sliding mesially (Figure 11.10(b)). It is important to remember that in this situation the distal ends of the archwire must be turned upwards hard behind the molar tubes to prevent the archwire sliding mesially.

Nickel-titanium coilsprings are particularly useful, offering a long range of action while applying relatively light forces. As a guide, the coilspring should be compressed to half its passive length, and the canine ligature must be sufficiently loose to allow the bracket to slide along the archwire.

Canine alignment using sectional archwires

A sectional archwire enables the distal movement of a canine together with the archwire. The situation is to be distinguished from sliding mechanics. Unpredictable frictional losses between the canine bracket and the archwire are eliminated, and all available anchorage can be concentrated on canine retraction.

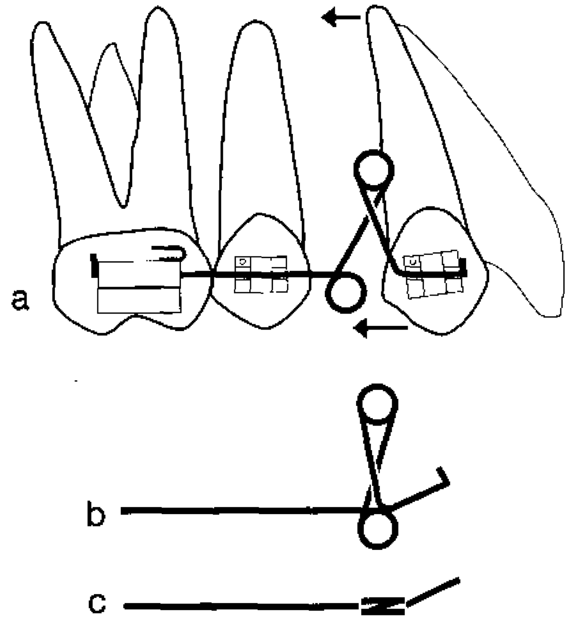
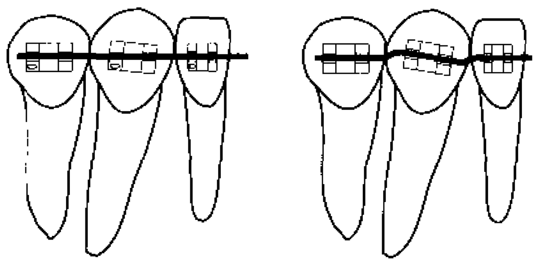


Figure 11.12 Rectangular sectional archwire for canine retraction: (a) activated by pulling the archwire distally and turning the end up distal to the molar tube; (b) passive, showing adjustment designed to move the canine apex distally; (c) passive, plan view, from above showing adjustment designed to oppose mesiobuccal rotation of the canine

It is often necessary to begin with a succession of round plain sectional wires in order to achieve bracket levelling.

The sectional archwire used to produce distal movement incorporates helixes which can be activated to apply a distal force to the canine (Figure 11.12). It is necessary to use rectangular wire because round wire sectionals rotate in the brackets, leading to impaction of the helix in the neighbouring soft tissues and unpredictable force activation.

The archwire lying in the canine bracket must be adjusted to resist unwanted tipping or rotation of the canine as it moves distally – but even when such adjustments are made it is in practice impossible to achieve true bodily retraction of the canine. A sectional archwire offers poor control of buccal flaring and mesiobuccal rotation of the canine as compared to sliding



a b

Figure 11.13 A preadjusted bracket, (a), gives the correct canine angulation, whereas archwire bends are required when (b), a standard edgewise bracket is used

mechanics used on a continuous archwire. Sectional archwires also tend to produce excessive extrusion of the canine despite the incorporation of anchorage bends distally.

When using 0.022 in edgewise brackets, 0.017 × 0.025 in stainless steel rectangular wire is an appropriate size for the construction of sectional canine retractors, Some operators prefer to use a much more flexible rectangular wire, such as nickel-titanium, accepting the inferior level of control it offers in exchange for reduced strain on the anchorage.

The rigidity of stainless steel rectangular wire sectionals means that they must be activated with great care to avoid the application of unacceptably high forces to both the canine and the anchorage teeth. Even so, sectional archwires tend to place considerable strain on the anchorage, and anchorage reinforcement is usually advisable.

When the canines have been retracted using sectional archwires the incisors are bonded and continuous archwires used to complete treatment. The canine crowns must be tied back in order to prevent relapse of their position.

Detailing of canine position

The methods which have been described for movement of canines using edgewise brackets usually mean that detailed adjustment of angulation, rotation and vertical position will be needed. When standard edgewise brackets are in use, the later mid-treatment and retention archwires are adjusted to incorporate bayonet bends in the horizontal and vertical planes as required (Figure 11.13). When preadjusted brackets are used the need for these detailing bends will be at a minimum – providing of course that the brackets have been correctly positioned.

Canine alignment using Begg brackets

In the Begg technique, the canines and incisors are moved together as a block. Unless the brackets are fitted with auxiliary springs the teeth will be relatively free to tip and so the forces applied, and the anchorage demands, will be low. When the crowns of the teeth have been moved into the prescribed positions uprighting springs must be applied to produce apical movement and bring the teeth to their correct angulation (Figure 4.14). As far as canine alignment is concerned, the process involves tipping followed by uprighting. The intrinsically imprecise relationship between round archwire and the Begg bracket makes detailed correction and retention of tooth position difficult. On the other hand, very considerable amounts of tooth movement can be accomplished using only light forces and intra-oral anchorage.

Severely displaced canines

Palatal canines

The alignment of severely displaced palatal canines is a relatively common orthodontic procedure. In difficult cases the duration of treatment will be over two years. Fixed orthodontic appliances will almost always be necessary, although removable appliances can be useful at certain stages of treatment.

Assessment of the canine's position, angulation and relationship to neighbouring teeth is obviously of prime importance when deciding the detail of treatment. Sufficient space in the arch must be made available. The path along which the canine is to be moved must be clear of obstruction, particular care being taken to avoid bringing the canine into contact with the roots of other teeth because of the risk of root resorption.

There are basically three mechanical stages in the alignment of a palatal canine following any necessary surgical exposure. The first stage involves the creation of sufficient space into which to move the canine. It is wise to provide a slightly greater space than might appear necessary because the canine is unlikely to be at

its ideal angulation as it is being moved into the arch, and its crown will therefore occupy additional space. The second stage is concerned with the movement of the crown in a buccal and occlusal direction into its correct location in the arch. The third stage involves detailing of the canine's angulation, apical and vertical position, and rotation.

The canine crown will often need to be moved a significant distance both buccally and occlusally. The vertical and horizontal anchorage demands will be considerable, and it will be necessary to provide sufficient resistance to avoid the possibility of the anchor teeth being moved into unacceptable positions.

The movement of the crown of the canine into its correct position in the arch will be accompanied by tipping of the tooth. It will be necessary to correct the angulation and vertical position of the tooth, together with its rotation, when the crown has been moved across the bite. With regard to angulation, it may be necessary to adjust the position of the canine apex both mesiodistally and buccopalatally. Edgewise brackets, by virtue of the control they offer in all planes of space, are particularly appropriate for the final alignment and retention of palatal canines when used with rectangular archwire.

From the point of view of stability, there must be sufficient overbite at the end of treatment to prevent relapse of the canine crown in a palatal direction.

Surgical uncovering of the crown

When the canine is unerupted it may be decided to arrange surgical exposure of the crown. In this situation, a bonded attachment can be fitted to the canine crown at the time of surgery, or later at the time of pack removal. Some operators choose to delay the fitting of an attachment to the canine for up to six months while the tooth erupts into a better position.

The design of the attachment at this stage is not critical – the objective is to obtain a point of attachment for an elastic or ligature wire on the crown of the canine, and a Begg bracket, button or cleat can be used. Although it is usually impossible to place the attachment in the ideal position because of difficulty of access, consideration should be given to the location of the attachment because it can assist movement of the canine in the required direction. Providing that the canine crown has been sufficiently exposed, that it is not excessively deep, and that an attachment has been bonded in position, spontaneous re-covering of the crown is very unlikely to occur. A significant amount of spontaneous improvement in the canine position is often seen following surgical uncovering, and it is usually advisable to delay the application of traction for at least four to six weeks.

Some operators choose to use a fine gold chain attached to the canine as a point of attachment.

Alignment using removable appliances

When the canine crown is already erupted and readily accessible it may be decided to begin its buccal movement using a removable appliance. The position and morphology of the canine crown usually means that a palatal cantilever spring cannot be used.

A hook is bonded to the canine crown. The removable appliance is designed with a hook buccally, and the patient is instructed in the application of a latex elastic ring between the two hooks. The removable appliance provides excellent vertical and horizontal anchorage for the occlusal and buccal movement of the canine, and bite platforms can be incorporated so that the canine can be moved across the bite. Final positioning will usually require the fitting of brackets to the remaining teeth in the arch and the use of a series of archwires.

Alignment using fixed appliances

When the attachment on the canine crown is in place, traction can be applied. The upper first molar teeth are banded and a soldered palatal arch is used to augment the anchorage. Some operators use a palatal acrylic button on the anterior slope of the palate to add to the resistance of the molars to mesial tipping as the canine is moved occlusally.

In general, the preferred method of force application is to apply traction to the canine crown in a buccal direction using elastic thread.

A useful method of managing the buccal traction is to place a short rigid length of rectangular wire in the molar tube (Plate 20). The wire incorporates a ring at its anterior end. Elastic thread runs from the canine attachment to the molar hook, passing through the wire ring. The length of the elastic thread provides for a satisfactory range of action. The mesiodistal

positioning of the ring will determine the direction of force applied to the canine.

Alternatively, all the remaining teeth in the arch can be fitted with attachments, and buccal traction applied to the canine when an archwire of sufficient rigidity (at least 0.020 in stainless steel) is in place. The archwire can incorporate a ring in the canine space to provide a point of attachment for the elastic thread.

As the canine improves in its position, the original attachment can be exchanged for an attachment in a more favourable position on the canine crown – perhaps assisting in rotation. The aim is to bond a bracket to the labial surface of the canine when sufficient of the crown is accessible.

The palatal canine or its attachment may come into occlusion with a tooth in the opposing arch. At this stage it may be necessary to fit a lower removable appliance incorporating bite platforms for a short period while the upper canine moves across the bite. Eventually it will be possible to bond an edgewise bracket to the labial surface of the crown and attach the tooth to a buccal archwire – initially one of low stiffness. Alteration in the location of the canine bracket may be required in order to bring the tooth to its correct vertical position, remembering the importance of ensuring sufficient overbite to prevent relapse.

Further improvement of the canine's position will be achieved using a series of archwires, rectangular wire being used for final detailing of the apical position.

Buccal canines

As with palatal canines, careful consideration of the position and angulation of the buccal canine is necessary when planning treatment. The amount of vertical movement required and the proximity of neighbouring tooth roots must be assessed. Sufficient space needs to be made available in the arch to accommodate the displaced tooth.

A buccal canine may require a significant amount of both distal and occlusal movement. The apex may need to be moved in a distal direction in order to bring the tooth to an acceptable angulation. Anchorage demands will be considerable and sufficient resistance must be provided to oppose the reciprocal forces associated with distal and occlusal movement of the canine.

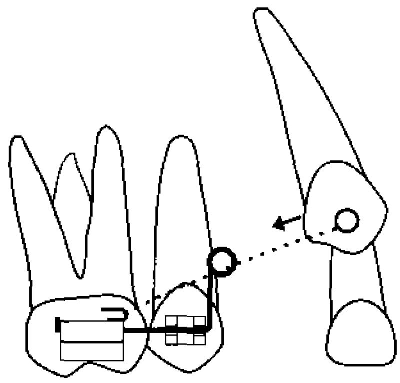


Figure 11.14 Distal movement of a buccally placed upper canine. The ring through which the elastic thread runs determines the direction of force. The canine will move more distally than occlusally, in order to avoid the lateral incisor root. A palatal arch attached to the molar bands is required to supplement anchorage

Severely displaced buccal canines will often require surgical exposure in order to provide access for the bonding of an attachment. When the canine crown is high in the sulcus the attachment needs to project as little as possible from the tooth surface in order to minimise the possibility of ulceration. A bonded button is generally appropriate.

The first molars are fitted with bands and a rigid soldered palatal arch incorporating a palatal acrylic button to augment the anchorage against occlusal movement. A short length of rectangular archwire is constructed with a ring at its mesial extremity. This wire is placed in the molar tube, and ligated to the premolar bracket.

Traction is applied using elastic thread running from the molar hook, through the ring, to the canine attachment. The direction of the force, both distally and occlusally, can be controlled by positioning of the ring (Figure 11.14).

Careful consideration must be paid to the path along which the canine will move so that it is not brought into contact with the incisor roots. It may be necessary to concentrate on distal rather than occlusal movement in the first instance.

When the canine crown is near its correct position, an edgewise bracket is bonded to its buccal surface. The remaining teeth in the arch are bracketed and canine alignment is completed using a series of buccal archwires.

It may be of advantage initially to use a sectional accessory archwire of low stiffness attached to the canine bracket (Figure 11.15). A

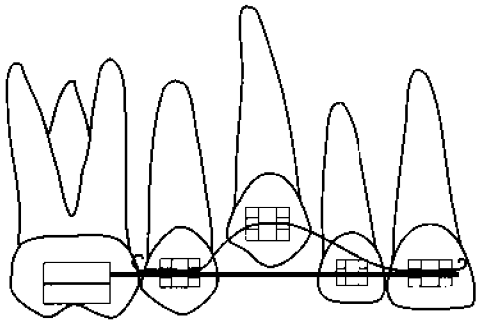


Figure 11.15 An accessory archwire of low stiffness to move an upper canine occlusally

relatively rigid base archwire enables other teeth in the arch to provide anchorage for improvement in canine position.

Canines simulating upper lateral incisors

The congenital absence of upper lateral incisors is a fairly common orthodontic problem. Sometimes a lateral incisor is missing on one side, and on the other side the lateral incisor is diminutive (a 'peg-shaped' lateral incisor). In this situation it may be decided to extract the diminutive tooth in order to achieve a more symmetrical appearance at the completion of treatment.

When a lateral incisor is missing, or has been extracted, it may be appropriate to move an upper canine mesially into a position in which it can simulate a lateral incisor. Ideally, the canine should be already upright or distally inclined, and with the labial surface facing buccally. In addition, the canine crown size, shape and colour should approximate that of a lateral incisor, bearing in mind that the appearance of teeth in the upper labial segment needs to be as symmetrical as possible at the end of treatment.

Edgewise brackets are particularly appropriate because precise positioning and retention of the canine is required. If the canine crown is appreciably wider labio-palatally than that of a lateral incisor, it is advisable to position the canine bracket further occlusally than usual so that the canine is relatively intruded. If pre-adjusted brackets are used some operators invert the canine bracket so that when rectangular archwire is in place root torque is applied to move the canine apex palatally.

It is generally preferable to use sliding mechanics to move the canine mesially into contact with the central incisor.

Initial alignment precedes the placing of a working archwire of, for example, 0.016 × 0.022 in stainless steel. Mesial movement of the canine along the archwire can be achieved using elastic thread, elastic chain or coilspring. The reciprocal effects of the active component need to be anticipated, remembering the inevitable anchorage requirements. Particular care may need to be taken to avoid unwanted movement of the centre-line.

When the canine has been moved into contact with the central incisor a steel ligature must be applied to prevent re-opening of the lateral incisor space while final detailing of the canine position is completed.

Following removal of the appliance precautions must be taken to prevent the tendency for the canine to move away from the central incisor. A palatal bonded retainer can be fitted, or a removable appliance retainer used for an extended period.

A further improvement in aesthetics can usually be obtained by grinding the canine cusp, and modifying the crown shape using composite resin or a porcelain veneer.

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12

Overbite management

This chapter is primarily concerned with the management of the incisors in a vertical direction. Most malocclusions require some control of the vertical position of the incisors during treatment.

A Class I incisor relationship is the aim of treatment in the majority of cases. In a Class I incisor relationship the lower incisors occlude on the middle third of the palatal aspect of the upper incisors. The average values for the angles of a Class I incisor relationship are shown in Figure 12.1. Although there is a range of variation of several degrees about these means, even in a Class I case, the labial segments are often at differing angles to the maxillary or mandibular planes, compensating for a mild Class II or Class III skeletal pattern.

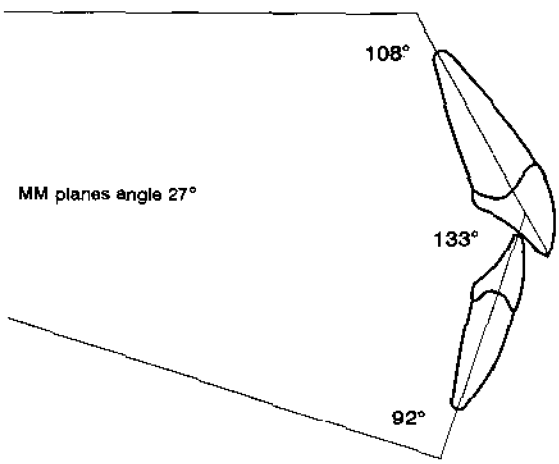

Figure 12.1 Class I incisor relationship and average angles

Aetiology of overbite

The vertical position of the incisors is influenced by a number of factors which are closely interrelated.

Increased overbite

Dento-alveolar development continues in a vertical direction until contact is made with an opposing tooth, the soft tissues or until the full eruptive potential is reached.

A situation in which the upper and lower incisors do not erupt into a Class I relationship may result in an increased overbite. If there is an anteroposterior skeletal discrepancy relative over-eruption of the upper and lower incisors will result in an increased overbite. Similarly, localized over eruption may occur when a tooth is unopposed, perhaps as a consequence of tooth loss.

If the interincisal angle is increased, contact between the lower incisor edge and the upper incisor cingulum may not occur resulting in relative over eruption and increased overbite.

A low maxillary mandibular planes angle is often associated with an increased overbite, both in Class II division 1 and Class II division 2 occlusions.

Reduced overbite

The presence of a mildly reduced overbite is rarely of clinical significance unless it is associated with the correction of a Class III incisor

relationship, where adequate overbite is needed to produce a stable result. A reduced overbite, or in extreme cases an anterior open bite, may occur in the following situations:

1. When the anterior lower face height is increased a skeletal discrepancy. The incisors reach their full eruptive potential without achieving the vertical relationship shown in Figure 12.1. A relatively minor stable reduction of an anterior open bite due to this cause may be possible by orthodontic means, but skeletal surgery will be required if a significant correction is to be achieved in severe cases.
2. Persistent habits such as digit sucking. The digit prevents the incisors reaching their eruptive potential. Termination of the habit offers good prospects of a stable improvement in the incisor relationship.
3. Occasionally an abnormality of tongue size or behaviour will prevent the incisors reaching their eruptive potential – again a situation in which orthodontic treatment alone offers poor prospects of improvement.
4. Rarely, there appears to be a deficiency of eruptive potential, and although orthodontic treatment may improve the situation, stability is not assured.

It is not uncommon for patients to exhibit a combination of factors which may give rise to an open bite. For example a patient with a high maxillary mandibular planes angle and a continued digit sucking habit. It can therefore be difficult to ascertain the prime cause of the open bite and the prognosis for the treatment outcome must be guarded.

Treatment considerations

Class II malocclusion

In the majority of Class II occlusions, in order to achieve a satisfactory interincisal relationship, overbite reduction is an essential part of treatment.

Many courses of treatment fail because insufficient attention has been given to reduction of the overbite prior to retraction of the upper incisors. If the overbite has not been adequately reduced, occlusal forces will prevent the complete correction of an overjet. Overbite reduction in a case with a very low maxillary mandibular planes angle can take a considerable time to achieve.

High-angle Class II cases with an open bite are also difficult to treat and care must be exercised not to extrude the posterior teeth during treatment so exaggerating the open-bite tendency. The effects of expanding the buccal segments in an attempt to correct a posterior crossbite should also be borne in mind. Expansion will tend to reduce the overbite, and this may be particularly unhelpful when the overbite is already minimal.

Class III malocclusion

In Class III malocclusions the overbite may range from being increased and complete through to an anterior open bite. Factors such as the degree of anteroposterior skeletal discrepancy and the anterior face height will influence the overbite.

Mild Class III malocclusions may have an increased overbite associated with a forward displacement of the mandible.

Marked Class III malocclusions with an increased facial height are likely to demonstrate an open bite which cannot be treated by orthodontic means alone.

The presence of a moderately increased overbite is often advantageous in a mild Class III malocclusion, where the stability of the incisor relationship correction depends upon a positive overbite at the end of treatment.

A general principle in the management of Class III occlusions, is to avoid any intrusion of the incisors or any extrusion of the posterior teeth during treatment.

Principles of overbite management

Overbite control is related to many of the presenting features of a malocclusion. The extremes of high and low maxillary mandibular planes angle present different problems in management. The ways in which movement of the teeth can influence the overbite are:

- extrusion of the buccal segment teeth;
- intrusion of the buccal segment teeth;
- extrusion of the incisors;
- intrusion of the incisors;
- changes in the angulation of the labial segments;
- changes in the sagittal skeletal relationship.

Buccal segments (extrusion)

The correction of either an increased overbite or anterior open bite is closely related to the height of the posterior teeth and alveolar development. The vertical relationship of the incisors is affected by the hinge action of the mandible.

Vertical extrusion of the molars alters the relationship of the incisors by temporarily increasing the maxillary mandibular planes angle (Figure 12.2). Extrusion can be achieved either by active movement with orthodontic appliances or by allowing differential eruption to take place. Distal movement of the upper molars without intrusion also reduces the overbite, because of the wedge effect on the position of the mandible when these teeth are moved posteriorly (Figure 12.3). Any extrusion of the buccal segments is likely to be temporary, but can be used to allow correction of the incisor relationship. Once the overbite is corrected and appliances removed the underlying maxillary mandibular planes angle will revert to its pre-treatment value (Figure 12.4).

Extrusion of the buccal segment teeth commonly occurs as a combination of growth and the use of archwires to level the occlusal plane. Most mechanisms which are designed to intrude the labial segments also have a reaction which is to extrude the molars.

Buccal segments (intrusion)

Theoretically intrusion of the buccal segment teeth will effectively reduce an anterior open bite

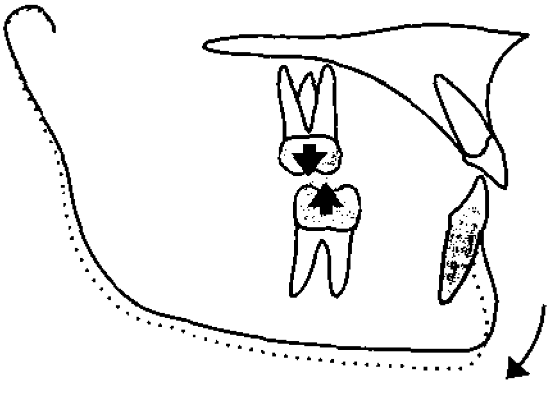

Figure 12.2 Extrusion of the molars alters the vertical relationship of the incisors

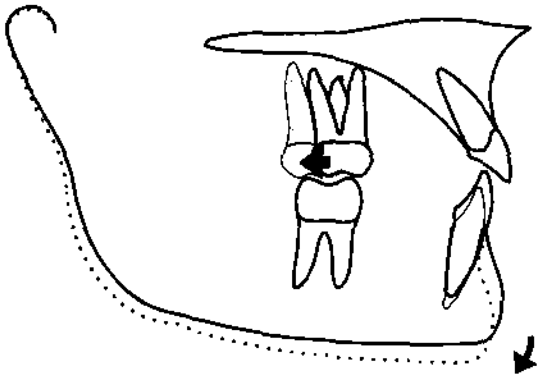

Figure 12.3 Distal movement of upper molars without intrusion aids in overbite reduction

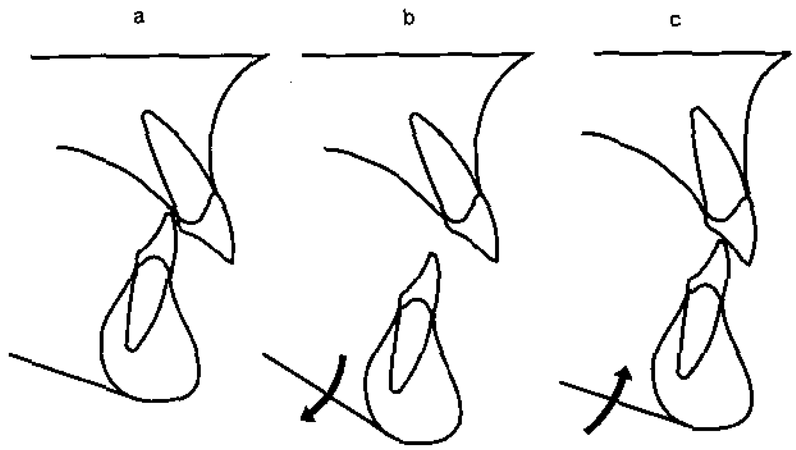

Figure 12.4 Reduction in overbite causes a temporary increase in maxillary mandibular planes angle which reverts to its original value after treatment: (a) before treatment; (b) after overbite reduction; (c) the reduced overjet maintains overbite reduction

by temporarily reducing the maxillary mandibular planes angle. Unfortunately the improvement in open bite which follows intrusion of the buccal segments is likely to relapse as the maxillary mandibular planes angle reverts to its original value. The incisors are not held in a new position of stability and move apart from each other. By contrast, the change in incisor relationship that occurs when an overbite is reduced can give a stable reduction, because the incisors are in contact and remain so when the maxillary mandibular planes angle reverts to its original value (Figure 12.4).

Labial segments (extrusion)

Extrusion of the labial segments will increase the overbite or reduce an anterior open bite. However there is a limit to the amount of movement that can be carried out because the supporting alveolar bone will only adapt to a limited extent. In extreme open-bite cases extrusion of the incisors in an attempt to achieve a positive overbite is inadvisable.

Labial segments (intrusion)

Intrusion of the lower incisors will reduce the overbite. This is the movement which is most commonly needed to obtain a satisfactory incisal relationship. True intrusion of the lower incisors is difficult to achieve even when using fixed appliances. Most of the apparent intrusion occurs by elevation of the posterior segments particularly in the mandibular arch.

To achieve intrusion it is important to ensure that there is sufficient height of alveolar bone. Light force must be employed as all the pressure is concentrated at the apices of the incisors. The direction of the applied force must also take account of the shape of the supporting bone to avoid the incisor apices impinging against the cortical plate with resulting delayed tooth movement and possible apical resorption. Care must also be taken to avoid proclining the incisors. Mechanically it is extremely difficult to intrude teeth without associated tipping.

Vertical intrusion of the upper incisors is required when there is an excessive clinical crown height associated with an exaggerated reverse curve of Spee. Intrusion may also be indicated when there is an unacceptable degree of incisor exposure due to a short upper lip. The management of upper incisor intrusion is difficult and may be undertaken by similar fixed appliance methods to those used for reducing an overbite in the lower arch. In addition high-pull extra-oral force may be applied by means of 'J' hooks to hooks on the archwire in the incisor region, to supplement intra-oral methods of intrusion (Figure 9.2).

Labial segment angulation

The angulation of the labial segments is also influential in the control of the overbite. Where the incisors are retroclined, as in a Class II division 2 malocclusion, there is a high interincisal angle often resulting in an increased overbite. Proclination of the incisor crowns accompanied by palatal torque of the apices can, in these cases, result in a reduction of the overbite and an improvement of the interincisal angle (Figure 12.5). Such cases are not easy to treat and are not recommended for the newcomer to the use of fixed appliances.

Importance of growth

All of the tooth movements described to reduce or increase an overbite are more likely to be successful in the young patient than in the adult. During growth, the differential eruptive potential of the teeth can be utilized. In those for whom growth is complete it is much more difficult to achieve a vertical alteration of incisor relationship. In adults, overbite reduction is a slow

Figure 12.5 Class II division 2 malocclusion showing how palatal root torque and proclination of the labial segments results in a changed interincisal angle which maintains the reduction in overbite

process and it is difficult to predict with certainty whether sufficient reduction of the overbite will be obtained.

Extraction considerations

In most cases the choice of extractions is closely related to the labial segment inclination. It is particularly important in the lower arch, where closure of extraction space following the relief of crowding can result in retroclination of the lower incisors and an increase in overbite. In a Class III case retroclination of the lower incisors will be an advantage but in a Class II malocclusion with a deep overbite the choice of extractions in the lower arch must take these factors into account. This is especially relevant in Class II division 2 cases.

In an apparently uncrowded arch, with an increased curve of Spee, levelling of the arch requires a certain amount of space. The cumulative mesiodistal dimension of the teeth in the arch and the arch length need to match if there is to be no crowding. When there is an exaggerated curve of Spee flattening of the curve will result in an increased arch length with possible labial movement of the lower incisors and the potential for post-treatment crowding (Figure 12.6). Extractions therefore may have to be considered even though the arch appears well-aligned.

In cases with mild crowding, a high maxillary mandibular planes angle and an increased anterior face height, distal movement of the upper posterior teeth may give an unwanted extrusion of the molars. In such occlusions it is wise to extract in the middle of the arch and avoid a possible increase in posterior face height.

Cases with a bimaxillary proclination of the labial segments present problems of stability following treatment. Reduction of an overjet in such cases cannot be achieved without retroclination of the lower incisors, which usually necessitates extractions if the arches are not already spaced. The stability of the result in such cases may be in doubt with a possibility of space re-opening at the end of the retention phase (Figure 12.7).

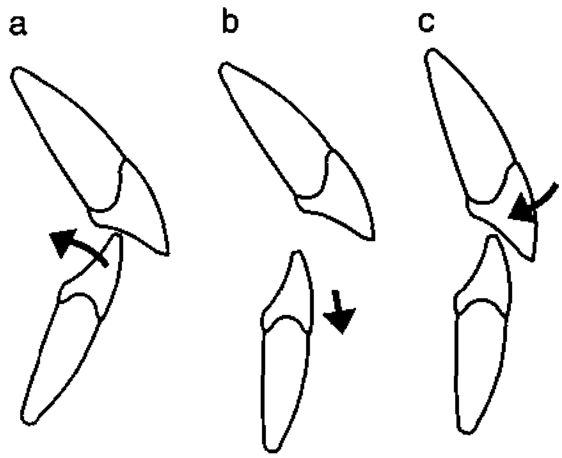

Figure 12.7 In a bimaxillary protrusion the lower labial segment must (a) be retroclined, and (b) intruded prior to overjet reduction (c)

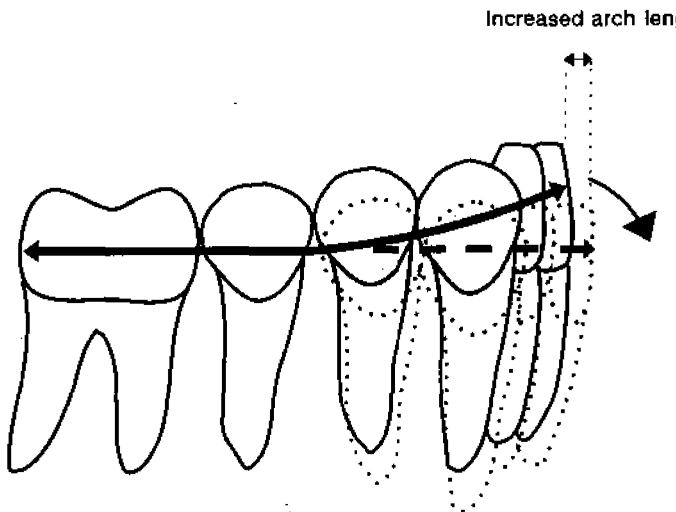

Figure 12.6 An exaggerated curve of Spee disguises an increased arch length

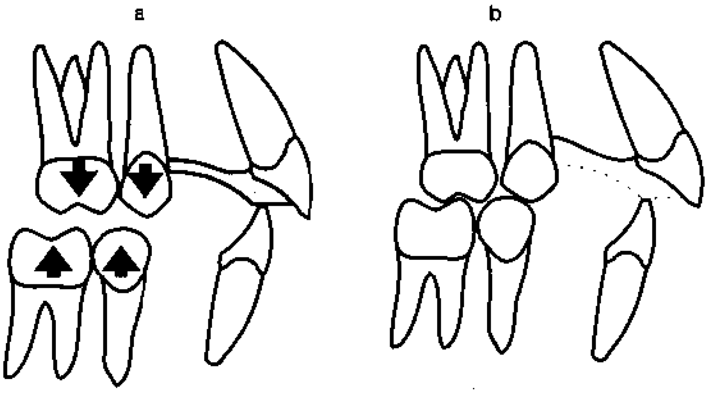

Figure 12.8 Fitting a removable appliance with an anterior bite plane (a) permits vertical development of posterior teeth with a consequent reduction of overbite. (b)

Methods of overbite reduction

Removable appliances

In the growing patient an efficient method of overbite reduction is the use of an upper removable appliance, incorporating an anterior bite plane. Such an appliance may be used as a preliminary stage of treatment prior to fitting fixed appliances. In Class II division 2 malocclusions with excessive overbite, the appliance will enable clearance for the lower incisor brackets to be bonded.

Using removable appliances, overbite reduction occurs by inhibiting vertical development of the lower incisors and allowing differential eruption of the posterior teeth to take place. The lower incisors are not intruded (Figure 12.8).

The anterior bite plane on the removable appliance should be just thick enough to disengage the posterior teeth by 2–3 mm. It should be flat and only extend posteriorly sufficiently far to engage the lower incisors. With full-time wear of such an appliance, within about two months the posterior teeth will be in occlusion, and the overbite will be reduced. By addition of cold cure acrylic to the bite plane the vertical dimension can be further increased. Maintenance of overbite reduction will require a lower fixed appliance. Before the upper removable appliance is discarded, the lower arch should be fully bonded and an archwire fitted of sufficient dimension to maintain control of the vertical position of the incisors (for example 0.018 in stainless steel).

Archwires for overbite reduction

Continuous archwires

The action of a continuous archwire in reducing an overbite is primarily by extrusion of the posterior teeth rather than by intrusion of the incisors. For those patients where an increase in the lower face height can be tolerated, which is the case in the majority of growing patients with average or low maxillary mandibular planes angles, continuous archwires are an appropriate method of overbite reduction.

In a patient with an increased overbite there is usually an exaggerated curve of Spee in the lower arch and continuous archwires are an effective method of levelling the occlusal plane. Initial aligning archwires, for example nickel-titanium or multistrand archwires, are too flexible to achieve any degree of overbite reduction. Some nickel-titanium archwires are available which have an exaggerated curve in the horizontal plane to obtain overbite reduction.

It is only when more rigid stainless steel archwires are in place that the effect of a flat archwire can have an influence on the vertical level of the incisors. When a flat archwire is placed in the lower molar tubes it will tend to lie passively beneath the lower incisor brackets (Figure 12.9). The insertion of the archwire into the incisor brackets will commence levelling the lower arch. In practice 0.016 in round stainless steel archwires are the first wires that begin to have an effect on the overbite. As incrementally thicker round or rectangular archwires are

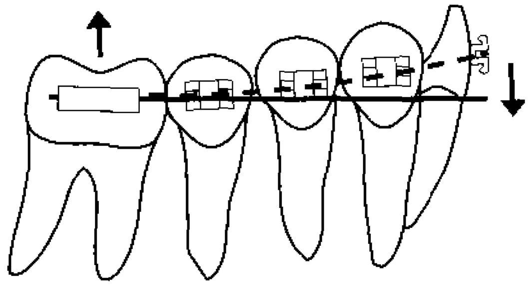

Figure 12.9 A flat archwire will depress the lower incisors

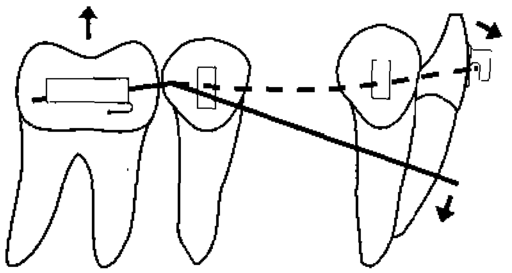

Figure 12.10 Anchorage bends extrude lower molars and intrude incisors

fitted the overbite can be reduced further. Incorporation of the second molars in the appliance system will aid in levelling of the arch.

Anchorage bends

Anchorage bends can be placed in the archwire immediately mesial to the lower first molars, which in addition to improving the anchorage value of the molars also aid overbite reduction. The reaction to the bend is an intrusive force applied to the lower incisors and an extrusive force applied to the molars. The molars may also be tipped distally and the effect on the molars is discussed in Chapters 2 and 8. Class II intermaxillary traction is often used to limit the distal tipping and also to aid overbite reduction by further extruding the molars.

In the Begg technique an 0.016 in or 0.018 in archwire, incorporating an anchorage bend of between 20° and 30° to the horizontal (Figure 12.10) is inserted into the molar tubes and engaged into the incisor brackets. The archwire is not fitted into the brackets on the second premolars. This gives a long lever arm which produces a low force delivered over a long range. The archwire when inserted in its passive state,

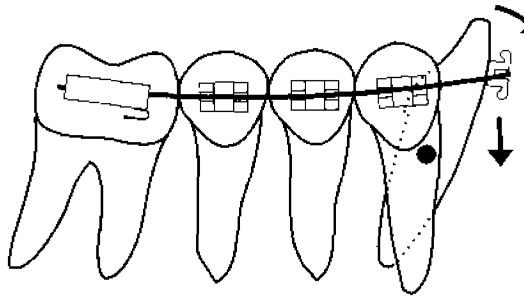

Figure 12.11 An intrusive force applied to the anterior teeth will result in proclination if the force is applied anterior to the centre of resistance

will rest approximately 1 cm gingival to the incisor brackets. The archwire requires elevating to engage it into the brackets. Because the teeth are free to rotate around the archwire there is a chance that the incisor apices will impinge against the lingual cortical plate which will delay movement. Proclination or retroclination of the incisors may occur, depending upon the relationship between the direction of force and the centre of resistance of the incisors (Figure 12.11).

Although anchorage bends were developed for the Begg technique, a modification can also be used in the edgewise system to aid overbite reduction. Initially a stainless steel round wire arch with an anchorage bend should be used. Later in treatment a reverse curve of Spee in the lower arch and an exaggerated curve of Spee in the upper arch should be constructed in rectangular wire. The archwire when it is placed in the molar tubes should lie 2–3 mm gingival to the incisor bracket slots. Lingual crown torque may be added to the rectangular archwires to reduce incisor proclination during overbite reduction and maintain the incisor roots in the cancellous bone.

Anchorage bends or a reverse curve of Spee are an effective way of reducing an overbite, which occurs by elevation of the buccal segment teeth and some intrusion of the incisors.

Reverse curve of Spee

When the initial alignment is complete, archwires may be constructed with a reverse curve of Spee to aid incisor intrusion. A reverse curve of Spee can be bent into high-tensile round or rectangular stainless steel archwires. Flat rectangular nickel-

titanium archwires are probably too flexible to obtain significant flattening of the lower occlusal plane. Overbite reduction can be achieved, however, with preformed rectangular nickel-titanium archwires with an exaggerated reverse curve of Spee. Theoretically they can apply light forces and because rectangular wires resist tipping, maintain control of the labio-lingual position of the incisor crowns. They can produce unwanted tooth movement and are not recommended for use by inexperienced operators.

Segmented archwires

Utility arch

The Ricketts technique is a treatment system based on edgewise brackets. It relies upon the use of a number of segmented archwires. The archwire designed to reduce the overbite is called a 'utility arch' and engages the molars and the lower incisors only (Figure 12.12). It is preferable for the lower incisors to be well-aligned before the archwire is placed. In order to restrict the amount of molar extrusion, sectional arches engaging the molars and premolars should be fitted in the buccal segments. Double buccal tubes are required on the lower molar bands to enable both the utility arch and the sectional arch to be incorporated. The archwire is stepped down in the buccal segment area to give a long lever arm, and is stepped up immediately distal to the lower incisors.

This step down also prevents the unsupported archwire from being damaged by the occlusion. It is often made in square section archwire, and is constructed with an angulation in the buccal segments that is similar to that of an anchorage bend in the Begg technique.

The anterior section of the archwire is constructed with slight lingual crown torque to limit labial movement of the lower incisor crowns. The use of square or rectangular section archwire ensures that the force can be directed down the long axis of the tooth and proclination or retroclination of the incisors can be minimized.

The effect of the archwire is to lower the level of the incisors and a step appears between the incisors and the canines. Once the overbite is sufficiently reduced the canines are incorporated into the system by progressively ligating them to the archwire until the whole arch is at the new level.

There is some evidence that the utility arch is one of the most effective fixed appliance mechanisms for incisor intrusion. Many operators therefore incorporate a Ricketts utility arch during treatment although not necessarily employing the full Ricketts technique.

Burstone intrusion arch

The Burstone intrusion arch is an accessory arch which is activated to apply an intrusion force to the labial segments. It is claimed that this technique can produce four times more true incisor intrusion than molar extrusion and is therefore the treatment of choice for overbite reduction in adult patients.

All the posterior teeth, premolars, first and second molars are combined into an anchorage unit by fitting full thickness rectangular archwires and linking the molars with a rigid palatal or lingual arch. The six anterior teeth are held together by an anterior sectional archwire following initial alignment. The intrusion force is applied by means of an accessory arch which is fitted in an additional molar tube (Figure 12.13). It is advised that the accessory arch is activated gingivally to apply a force of 30 grams and is ligated to the anterior sectional archwire in the canine region. The accessory arch does not

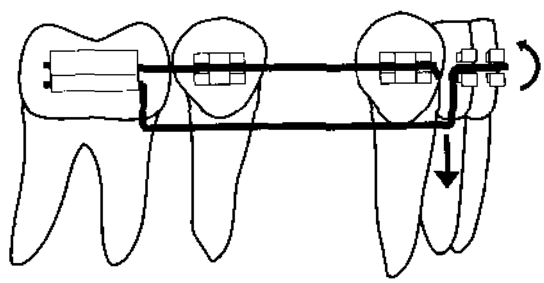

Figure 12.12 A Ricketts utility arch to intrude lower incisors. The labial section incorporates lingual crown torque

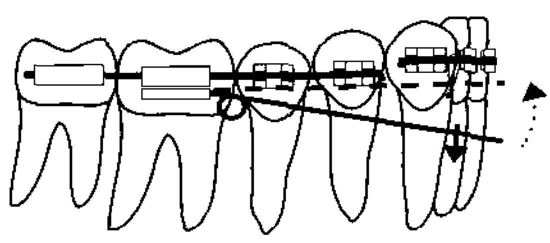

Figure 12.13 A Burstone intrusion arch

engage any of the anterior brackets and incisor proclination is theoretically avoided. Once again double buccal tubes are required on the lower first molar bands.

Supplementary methods of overbite reduction

Intermaxillary elastics

Elastic traction from the posterior aspect of the lower arch to the anterior aspect of the upper arch – class II elastics – can assist in overbite reduction. The action of the elastics is to reduce the overbite by obtaining extrusion of the molars. Because the elastics are attached to the archwire at the front of the upper arch some extrusion of the upper incisors may take place (Figure 12.14). Class II elastics can be used in a triangular configuration with the elastic extended from the lower molar to the upper molar to encourage extrusion of the posterior teeth (Figure 12.15).

Although class II elastics can be used in edgewise techniques to assist in overbite reduction, they form an essential component of overbite reduction in the Begg technique in conjunction with the routine use of anchorage bends in both the upper and lower archwires.

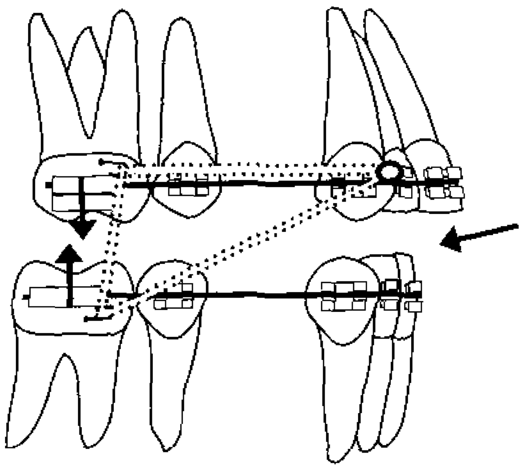

Figure 12.15 Class II traction placed in a triangular manner applies an extrusive force to both upper and lower molars

Low-pull extra-oral force

When extra-oral force is applied to upper molars using cervical traction to a face bow the force is in a downwards direction, with an extrusive component on the upper molars, which aids overbite reduction. If in addition the molars are being moved distally the effect of the distal movement is to increase the maxillary mandibular planes angle, which also assists in overbite correction (see Figure 12.3).

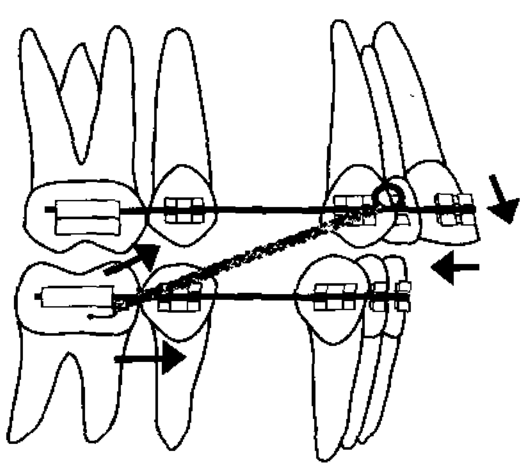

Figure 12.14 Class II traction applies a mesial and extrusive force on the lower molars and a distal and extrusive force on the upper labial segment

High-pull extra-oral force

Extra-oral force may be applied directly to the anterior part of the archwire by means of 'J' hooks to deliver an intrusive component of force to the upper labial segment. Hooks should be soldered to the archwire to accept the ends of the 'J' hook which can be constructed in closed loop form, thus reducing risks of facial trauma (see Figure 9.2).

Problems with overbite reduction

If overbite reduction is proving difficult, the following factors should be considered.

1. *Patient co-operation*, for example failure to wear elastics, bite plates or headgear as instructed
   - Explain to the patient the need to co-operate.

2. *The incisor apices are impinging against the cortical plate*
   - Apply torque to the labial segment to direct the apices towards the cancellous bone.
3. *Arch not fully banded and bonded*
   - Ensure that the posterior teeth including the second molars are banded and incorporated in the appliance system.
4. *Adult patient*
   - Overbite reduction is more difficult to achieve in adult patients and can be expected to take a longer time. In some cases it may have to be accepted that it is not possible to reduce an overbite, without recourse to orthognathic surgery.
5. *Unfavourable growth*
   - Mandibular growth rotation may be upwards and forwards (anti-clockwise) counteracting the overbite reduction. This will result in slow progress and treatment mechanisms cannot influence such changes.

Management of reduced overbite

Open bites associated with habits

The habitual sucking of a digit may lead to an open bite, usually in the anterior region. The resulting malocclusion will tend to be asymmetrical and rarely extend to the premolar region. A posterior crossbite is frequently found in association with a digit-sucking habit.

When treating patients with a habit activity it is essential to take account of the underlying skeletal pattern and any unfavourable soft tissues. Failure to do this may result in a corrected habit with little improvement to the malocclusion.

Where an open bite is due solely to a digit-sucking habit and the patient is actively growing, mechanisms to aid cessation of the habit may permit continued vertical development of the labial segments. With a Class I anteroposterior skeletal base relationship a normal overbite is likely to become established once the habit has ceased.

Treatment methods

1. Removable appliance

A removable appliance with a midline split may be useful in helping the cessation of a habit. If there is an associated unilateral crossbite with a displacement a midline screw can be used to correct the crossbite.

2. Palatal arch

A palatal arch which is soldered to bands on the upper first molars can carry an elevated section near the anterior part of the palate to remind the patient not to place the digit inside the mouth. In many persistent cases such an appliance is the most satisfactory way of correcting a digit-sucking habit. The appliance should be left in place for some months after the habit has apparently ceased to ensure that the patient has a continued reminder.

3. Extra-oral anchorage

Where extra-oral force is required to carry out upper arch tooth movement, the presence of a face bow may be sufficient to remind the patient to give up a habit. However if the patient has an increased anterior face height it is important not to extrude the molars with the extra-oral force.

Skeletally based open bites

An open bite of skeletal aetiology is associated with an increased lower face height and high maxillary mandibular planes angle. In extreme cases the only occlusal contact is on the terminal molars. A marked anterior open bite of skeletal origin will be impossible to treat by orthodontic means alone.

Attempts to extrude the incisors by the use of vertical elastics on the anterior teeth coupled with arch wires designed to extrude the incisors may be successful in the short term but the results are rarely stable.

Precautions during treatment of reduced overbite

If orthodontic treatment is to be undertaken for a patient with a high maxillary mandibular planes angle and a reduced overbite, it is important not to carry out measures that would increase the open-bite tendency. The following points should be considered:

1. The use of extra-oral force should be restricted to reinforcement of anchorage. Extractions in the premolar region are usually considered in

high-angle cases so as to avoid the need to move the molars distally.

2. If extra-oral force is used, an intrusive component of force should be applied to the face bow to prevent any extrusion of the molars.
3. Avoid the use of intermaxillary traction elastics which tend to extrude the molars.
4. Upper arch expansion should be carried out by bodily movement of the molars to prevent the palatal cusps of the upper molars from being extruded beyond the occlusal plane and opening the bite further.

Treatment of open-bite cases with a skeletal origin will usually require a combined orthodontic and surgical approach. For some patients the use of fixed appliances to align the labial segments without an alteration of their vertical relationship may give a satisfactory result, accepting the anterior open bite.

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13

Overjet management

This chapter is concerned with those movements of the incisors which are associated with producing change in the overjet, and change in the *interincisal angulation*.

Overjet reduction will be required in the treatment of Class II division 1 incisor relationship. It is achieved in the majority of cases by movement of the upper incisor crowns in a *palatal direction*.

Correction of Class III incisor relationship may involve movement of the upper incisor crowns in a labial direction and often movement of the lower incisor crowns in a lingual direction. *In Class II division 2 incisor relationship* correction of the angulation of the incisors to their dental bases is required.

Class II division 1 incisor relationship

Overjet reduction

Preparation for overjet reduction

It is *necessary, before embarking upon the* process of overjet reduction, to deal with marked vertical, labiolingual and rotational displacement of the upper incisors in the levelling and alignment stage of treatment (Chapter 10).

The overbite often needs to have been reduced before dealing with the overjet, and this reduction will need to be maintained during overjet reduction.

Space must be available into which to move *the upper incisors. Where the treatment sequence* demands it, the upper canines must have been moved distally into their correct positions (Chapter 11). In some techniques on the other hand, overjet reduction and canine retraction are *achieved together, in which case an increased* demand is placed upon the anchorage.

Overjet reduction is achieved in the mid-treatment stage, when archwires of sufficient stiffness to permit adequate control of tooth *position are in use.*

Angular change during overjet reduction

When a removable appliance spring is used to *achieve overjet reduction, the incisor crowns* move in a palatal direction but the apices move in a labial direction with angular change occurring about the tipping fulcrum (Figure 13.1(a)).

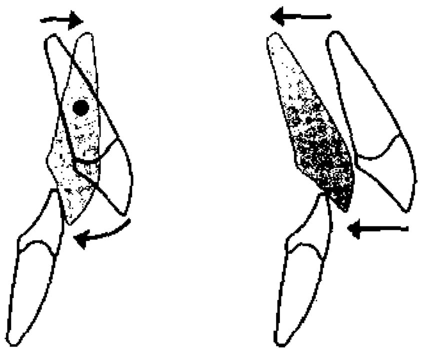

Figure 13.1 A comparison between overjet reduction by (a) tipping about a fulcrum within the root and (b) bodily movement in a palatal direction

The location of the tipping fulcrum influences the angular change, but it is not possible to predict with accuracy where the fulcrum lies. The inevitability of angular change places a limitation on the capability of such a mechanism for achieving controlled overjet reduction, because it may be necessary to move both the crowns and the apices in a the same direction, perhaps by different amounts (Figure 13.1(b)).

In some cases labial movement of the incisor apices during overjet reduction is desirable, or at least produces an adequate and stable interincisal relationship. This is particularly the case when the upper incisors are proclined before treatment and when there is only a small overjet to be reduced. If this is the situation, then a mechanism producing overjet reduction by incisor tipping may be quite appropriate.

In many other cases, however, any labial movement of the upper incisor apices is undesirable. The increased overjet may be associated with a Class II skeletal pattern, with the upper incisors at an acceptable inclination to the maxillary plane before treatment. If the overjet is reduced by tipping, the upper incisors will be retroclined at the end of overjet reduction, with an unsatisfactory appearance and a functionally unacceptable interincisal relationship. Movement of the upper incisor apices in a palatal direction is indicated in this situation.

Fixed appliances, like removable appliances, are capable of achieving overjet reduction by tipping of the upper incisors in a palatal direction. The advantage of fixed appliances lies in their ability to control the apical position (and hence the angular change occurring) during overjet reduction – where that is indicated. When fixed appliances are used to move incisor apices buccally or palatally, the procedure is referred to as 'torqueing' (Figure 13.2).

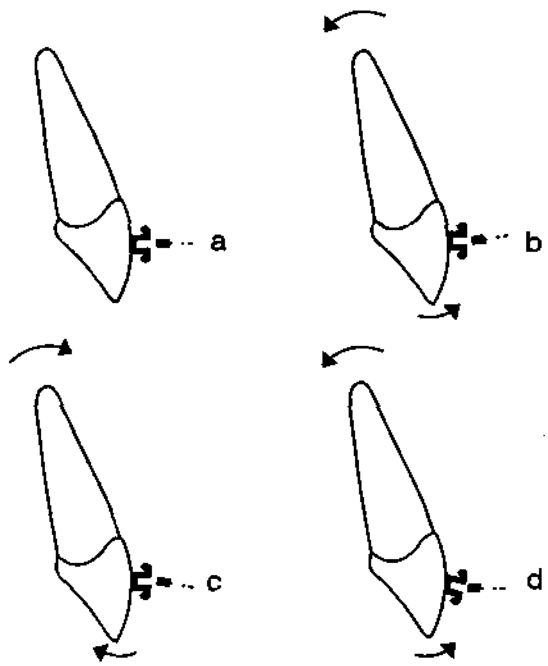

Figure 13.2 Torque using rectangular archwire: (a), (b), (c), standard edgewise brackets – (b) with palatal root torque; (c) with labial root torque; (d) preadjusted edgewise bracket with 'flat' archwire providing palatal root torque

Overjet reduction with edgewise brackets

Figure 13.3 illustrates a round wire overjet reducing mechanism. The canines have already been retracted. The archwire, constructed from 0.018 in diameter wire, incorporates a helix on each side which can be activated by pulling the buccal span distally and turning the end upwards. A palatally directed force is then applied to the incisors. Providing the helices are placed against the distal aspects of the lateral incisor brackets it will be possible to reactivate the mechanism at each appointment until the overjet is fully reduced. A retraction force of approximately 70 grams on each side is appropriate. Correct activation will require opening of the helix by pulling the archwire through the molar tube by approximately 3 mm on each side.

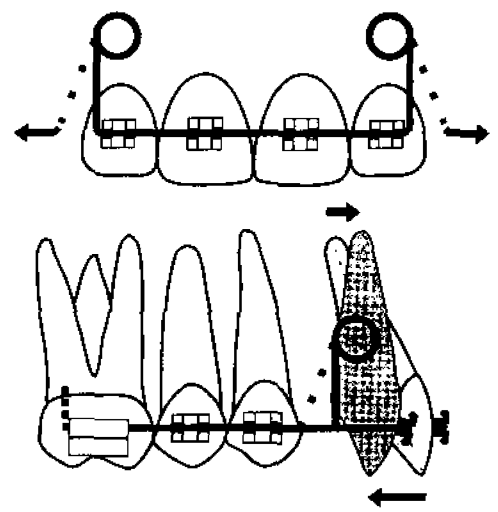

Figure 13.3 Overjet reduction using round archwire and edgewise brackets

Anchorage is provided by the upper molars, premolars and canines, which can be expected to move mesially, representing anchorage loss. If movement of the teeth providing anchorage is to be prevented, then their resistance to forward movement must be increased – for instance by using extra-oral traction applied to the upper molars.

A number of variations on this basic mechanism are possible. In place of the helices, archwire hooks can be used (distal to the lateral incisors) to provide points for the attachment of latex elastics which run distally to the upper molar hooks. Alternatively, and if anchorage is available in the lower arch, the elastics can be attached to the lower molar hooks. In either case the upper archwire must be free to move distally through the bracket channels of the upper buccal teeth as the overjet reduces.

Because the incisor brackets are free to rotate around the archwire, the incisors will tip as the overjet reduces. The bracket–archwire relationship in the incisor region means that it is not possible to achieve full control over the movement of the apices.

Palatal torque

Following overjet reduction by tipping it may be necessary to correct the angulation of the incisors by moving their apices in a palatal direction. Figure 13.4 illustrates the use of a rectangular archwire to achieve palatal movement of the upper incisor apex.

The rectangular wire applies a **force couple** to the bracket. A force couple comprises two equal forces in opposite directions. One of the forces is directed labially, tending to move the incisor crown labially (Figure 13.4(b)), and the other force is directed palatally, tending to move the incisor root palatally (Figure 13.4(c)). If no other restraint on movement is applied, the force couple will produce tooth movement approximating more closely to that seen in (b) than that seen in (c). Movement (b) requires less bone resorption and deposition, and will occur more quickly than movement (c). If it is necessary to achieve the movement shown in (c), the mesial component of the force couple must be resisted by an additional force of equal magnitude, in a distal direction.

Figure 13.5 shows the use of a rectangular archwire to produce palatal root torque.

In Figure 13.5(a) the mesial component of the force couple is resisted because the archwire is turned up distal to the molar tube. The molar, premolar and canine provide anchorage, and forward movement of the anchorage unit is prevented by the use of extra-oral traction. The

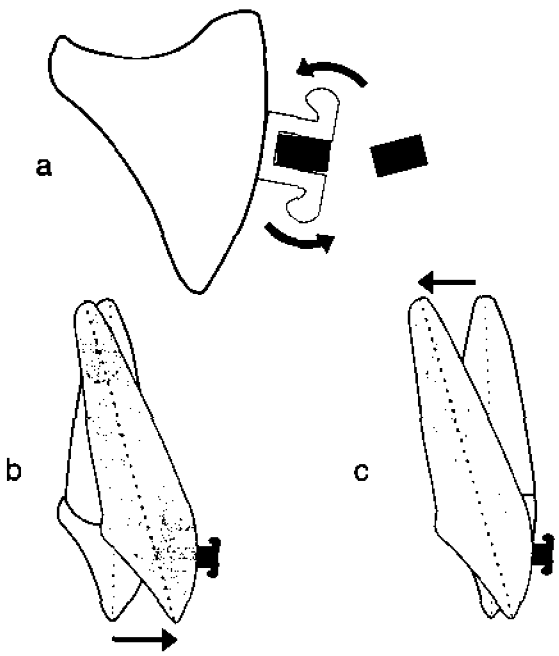

Figure 13.4 Palatal root torque: (a) the force couple; (b) and (c) show possible effects of the force couple

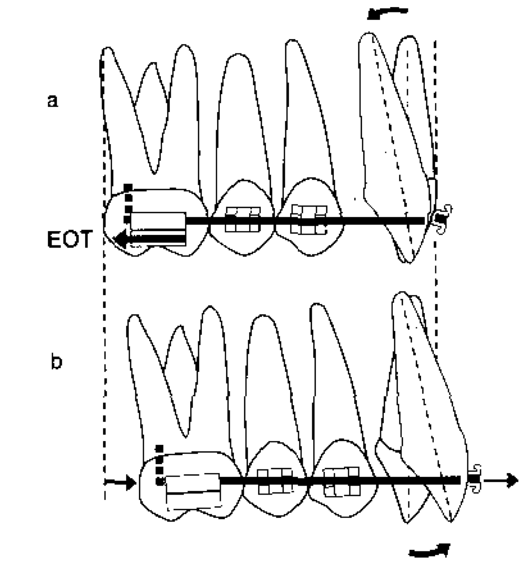

Figure 13.5 Rectangular archwire used to produce palatal torque of upper incisors: (a) anchorage reinforced with extra oral traction; (b) anchorage loss and increase in overjet

distal component of the force couple is effective *in producing palatal movement of the incisor* root, and there is no increase in overjet.

If the resistance offered by the anchorage is insufficient – for example, if extra-oral forces are not used, then the anchorage teeth will move forwards, and allow the mesial component of the force couple to be expressed as overjet increase (Figure 13.5(b)). It is important to recognize that if palatal movement of the upper incisor roots is required without overjet increase, greater strain will be placed upon the anchorage, which may well need to be reinforced. In addition, palatal movement of the incisor roots will occur relatively slowly.

The force required is higher than that needed for tipping movement. The labial span of the archwire will need to be snapped into the incisor bracket channels if it is going to apply sufficient force to produce palatal root movement. It is difficult to measure with accuracy the magnitude of the force couple, and experience is necessary if rectangular wires are to be used to apply torqueing forces in a safe and predictable manner. When moving from round to rectangular stainless steel wires it is usually wise, at an intermediary stage, to use wire of reduced stiffness – for example, rectangular nickel-titanium of 0.017×0.025 in. After this stage rectangular stainless steel of 0.016×0.022 in, and subsequently larger sizes, can be used.

If the brackets are of the preadjusted type then the use of a plain rectangular archwire will activate the torque programmed into the brackets. A sequence of 'flat' rectangular archwires of increasing stiffness and tighter fit in the bracket channel is used to express the torque built into the brackets.

When plain brackets are used, the labial section of the archwire must be twisted to incorporate torque.

Overjet reduction with apical control

An alternative to reduction of overjet by tipping followed by a separate torqueing stage is to use a mechanism capable of moving both the crowns and the apices of the upper incisors in a palatal direction at the same time.

Figure 13.6 shows the use of a rectangular archwire with standard edgewise brackets. The helix is activated by pulling the buccal span distally and turning up distal to the molar. The diagram shows **bodily** movement of the upper incisor in a palatal direction. In practice, however, unless the labial span is adjusted to increase the palatal root torque, the crown will move further palatally than will the apex, particularly if the archwire is a less-than-perfect fit in the bracket channels. When the overjet has been reduced, the application of a torque bend in the labial archwire span will produce further palatal movement of the incisor roots (Figure 13.6(b)).

Figure 13.7 shows a similar mechanism, but in this case preadjusted brackets are in use. In place of the helices, a distally directed force is applied to the incisors by means of an intra-

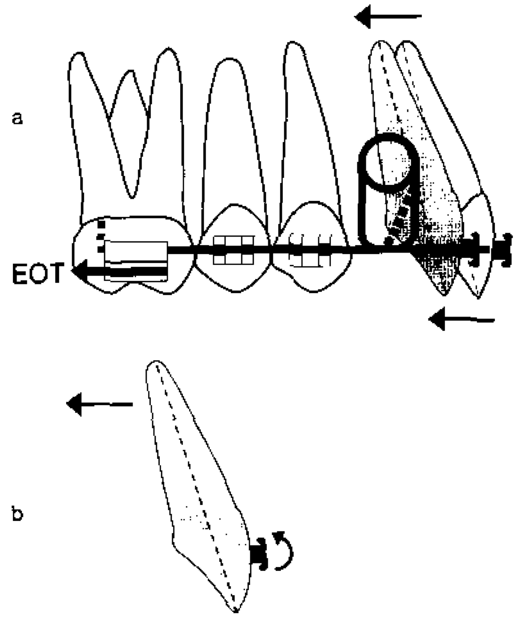

Figure 13.6 (a) Overjet reduction using rectangular archwire and standard edgewise brackets; (b) torque activation placed in the labial section to move the incisor apices further palatally

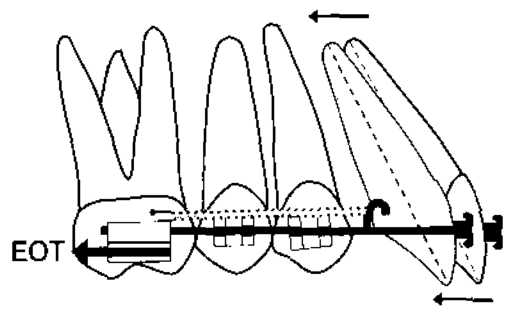

Figure 13.7 Overjet reduction using rectangular archwire and preadjusted edgewise brackets

maxillary elastic running between an archwire hook and the molar hook on each side. The archwire must be free to slide distally through the canine, premolar and molar attachments as the overjet reduces. The use of a sequence of rectangular archwires of progressively increasing stiffness will produce ideal incisor angulation without the need to place torque bends in the archwire.

In terms of anchorage management, a mechanism which enables overjet reduction with apical control will place heavy demands upon anchorage, and the use of extra-oral forces will almost certainly be necessary.

Methods of generating the force required for overjet reduction

There are basically two methods:

1. *Intramaxillary traction* (Figures 13.3, 13.6, 13.7.) The anchorage for overjet reduction is provided by the buccal teeth. The archwire may incorporate a closing helix which is activated by pulling the archwire through the molar tube and then turning it up. Alternatively, intramaxillary elastics can be used, but then the friction between the archwire and the brackets on the buccal teeth must be low enough to allow free sliding of the archwire in a distal direction (Figure 13.7).
2. *Class II traction* In this case the anchorage for overjet reduction is provided by the lower arch. The upper archwire design includes a hook on each side to which the elastic is attached as in Figure 13.7, but in this case the elastic is attached distally to the lower molar hook. The upper archwire must still be free sliding in the bracket channels.

It is essential to consider the effect of the class II traction in the lower arch. The mesial force applied to the molar hooks will move the molars forwards. This is desirable providing there is space into which the molars can be moved. If on the other hand there is insufficient space, all the lower teeth attached to the archwire will be moved forwards, and the danger is that they will be moved into unstable positions.

When intra-oral anchorage is insufficient, then it must be reinforced – for example by using extra-oral anchorage.

Overjet reduction with Begg brackets

In stage 1 of the Begg technique overjet reduction is achieved by tipping the incisors palatally and the canines distally, so that they become retroclined (Figure 13.8).

The round archwire allows the canines and incisors freedom to tip, and the anchorage requirement is low compared with that when edgewise brackets are used (particularly when they are used in conjunction with rectangular wire). Overjet reduction and upper canine retraction can usually be achieved without the need to support the anchorage with extra-oral traction because only light forces are required – 70 grams on each side. Intermaxillary class II elastics are used, so that the lower arch provides anchorage for tooth movement in the upper arch.

In stage 2, further incisor retroclination is obtained by using intramaxillary elastics. At this stage the incisor relationship is edge-to-edge, and the incisors in both arches are retroclined.

In stage 3 the basic bracket–archwire relationship is changed by the addition of a torqueing auxiliary to the base archwire.

Figure 13.9 shows a type of round wire torqueing auxiliary. The auxiliary is wound onto the base archwire, and delivers palatally directed force to the incisor crowns gingivally to the

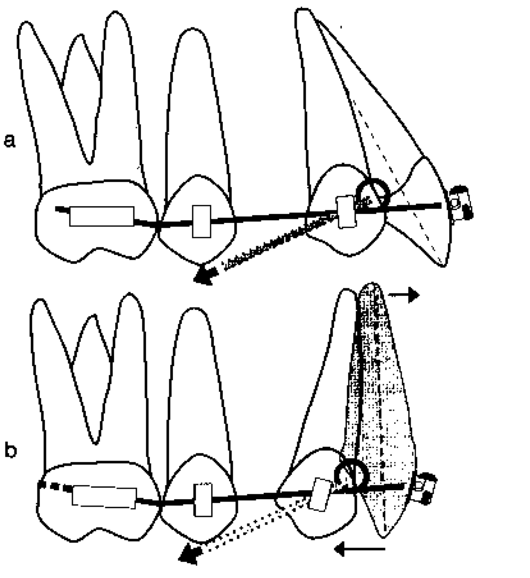

Figure 13.8 Overjet reduction using Begg brackets, round archwire and class II intermaxillary traction: (a) before, and (b) during overjet reduction

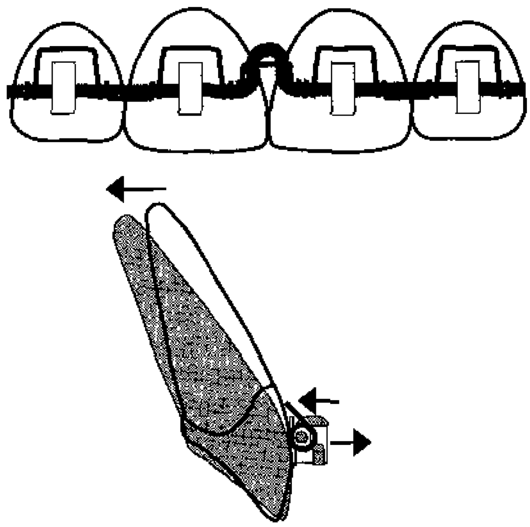

Figure 13.9 Torqueing auxiliary for use with Begg brackets. The auxiliary is wound onto the base archwire and is active to move the incisor apices in a palatal direction

bracket channels. The auxiliary has a much greater range of action than a rectangular wire in edgewise brackets. The auxiliary is constructed from round wire of 0.014 in diameter, and is wound onto a base archwire of 0.020 in diameter. As with edgewise brackets and rectangular wire, a force couple is generated – this design of torqueing auxiliary can be modified for use with edgewise brackets when a roundwire arch is being used. The distal component of the couple moves the incisor roots palatally. Controlled movement of the upper incisor crowns in a labial direction is permitted in view of the palatal position of the incisor crowns seen at the end of stage 2.

At the end of stage 3 the labiolingual positions of the incisor crowns, and their angulation to the dental bases, will have been corrected.

It appears that the process of tipping followed by uprighting, as seen in the Begg technique, is particularly economical in terms of the overall demands placed upon intra-oral anchorage. An advantage of this approach is avoidance of the need for extra-oral anchorage. On the other hand there is only a finite amount of intra-oral anchorage available. In addition, the need to add torqueing auxiliaries makes the Begg mechanism particularly complicated in stage 3, so that it is difficult both for the orthodontist to control and for the patient to keep clean. Safe use of the technique demands experience. The Begg technique is not to be recommended for the beginner.

Class III incisor relationships

Proclination of the upper incisors increases the arch length and provides space for alignment of crowded teeth. Retroclination of the lower incisors reduces arch length, and space must be available in the lower arch if this movement is required.

Correction of Class III incisor relationship may involve proclination of the upper incisors and retroclination of the lower incisors. These movements are often stable because the incisors are not moved out of soft tissue balance, the upper and lower incisor crowns merely exchanging their labiolingual positions. The use of class III traction with upper and lower fixed appliances is a useful mechanism in this situation.

In Figure 13.10, the intermaxillary elastic applies a distal force to the lower archwire hook, tending to move the lower incisors in a lingual direction. The elastic applies a mesially directed force to the upper molar hook. The upper archwire carries a 'stop' which fits tightly against the mesial of the molar tube, so that force is delivered to the upper archwire. This results in movement of the upper incisors in a labial direction as the upper buccal teeth move forwards. The class III traction applies a distal force to the lower archwire, and the lower incisor crowns will move lingually. Labial movement of the upper incisors and lingual movement of the lowers will occur more readily when round archwires, which permit tipping, are used.

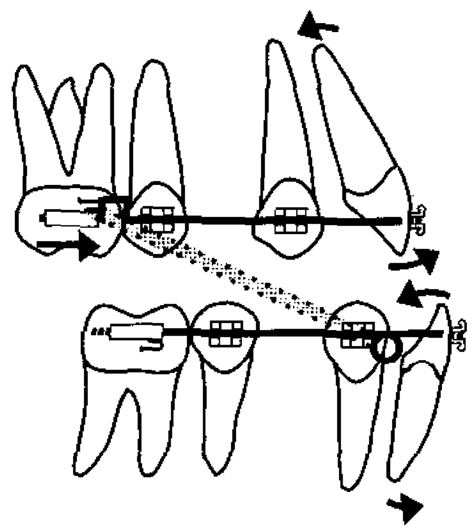

Figure 13.10 Class III traction used with edgewise upper and lower brackets and round archwire

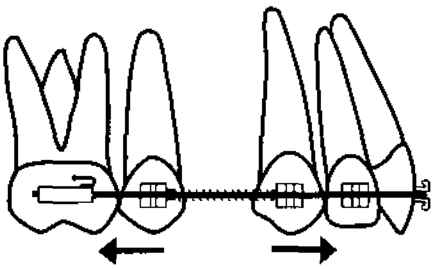

Figure 13.11 Compressed coilspring between brackets on canine and second premolar

Intramaxillary traction using compressed coilsprings supported on the buccal archwire span is another way of delivering a proclining force to the upper labial segment (Figure 13.11). The reciprocal force will move the upper molar and premolar distally, and this tendency may need to be resisted by the use of class III traction, or by using reverse headgear.

Retroclination of lower incisors can be produced by intramaxillary elastic traction in the lower arch, and by class III traction.

Stability of Class III incisor relationship correction is dependent upon a positive overbite. There is a danger of reducing the overbite if the upper incisors are free to tip as they procline, unless the archwire is modified by the incorporating of a reversed curve of Spee. Vertical elastics running between hooks mesial to the canines in both archwires are an effective mechanism for increasing the overbite.

Torqueing of incisors may be required after correction of the incisor relationship. When this is necessary, the upper incisor apices will usually need moving labially, and the lowers lingually. It will be necessary to modify the mechanisms described above under overjet reduction to produce torque in the required direction. Labial root torque applied to upper incisors tends to move the crowns palatally, and intra-oral anchorage may need to be reinforced – for instance by the use of a reverse headgear.

Class II division 2 incisor relationship

Class II division 2 is one of the most difficult malocclusions to correct. Both the upper and the lower incisors are retroclined, with an increased overbite and an increased interincisal angle. The excessive overbite is difficult to correct, particularly when there is a reduced maxillary mandibular planes angle. The aim of treatment is to establish a stable reduction of the overbite, but stability cannot be achieved without correction of the interincisal angle.

The two interconnected requirements – overbite reduction and correction of the incisor angulation – are particularly demanding in severe Class II division 2 cases.

In mild cases without a traumatic incisor relationship it may be decided to accept the basic incisor relationship and the increased overbite, but to achieve an improvement in aesthetics by bringing the upper lateral incisor crowns into line with the central incisors. The lateral incisors may be rotated, usually mesiolabially, and their apices may need to be moved labially as well as their crowns moved palatally. If that is the case then a fixed appliance will be necessary.

A round wire torqueing mechanism similar to that shown in Figure 13.9 can be used with edgewise brackets, with modification to produce palatal root torque of the central incisors and labial root torque of the lateral incisors.

An alternative to using a round wire mechanism would be to use rectangular wire. The labial section of the archwire will need to be activated carefully to apply torque in the required direction to the central and lateral incisors.

A difficulty presents itself at the end of tooth movement, because the correction is very unlikely to be naturally stable, and indefinite retention will need to be provided.

In traumatic Class II division 2 cases it is necessary to aim for a more radical reorganization of the interincisal relationship. This will involve reduction of overbite and correction of the incisor angulation in both arches, with the intention of completing treatment with a Class I incisor relationship. Treatment will usually involve labial movement of the upper and lower incisor crowns.

The excessive overbite and close contact between the upper and lower incisor crowns seen at the commencement of treatment may make the fitting of brackets in the lower incisor region inadvisable. Reduction of overbite can be commenced using an upper removable appliance incorporating a flat anterior bite plane. The appliance can also incorporate a mechanism for proclination of the upper incisors. At the end of this stage of treatment fixed appliances can be fitted in both arches, so that the overjet can be

reduced with a mechanism allowing apical control.

Severe Class II division 2 cases are among the most difficult to treat, demanding considerable expertise in terms of treatment planning and appliance management. The best results often require treatment involving a combination of removable, functional and fixed appliances, and sometimes skeletal surgery.

Summary

Improvement of the relationship between, and the alignment of, upper and lower incisors is one of the principal justifications for orthodontic treatment. It is the position of the incisors which is of greatest significance in terms both of dental and facial aesthetics. The duty of the orthodontist is to achieve for the patient the maximum aesthetic and functional improvement, with a stable result. This chapter outlines the mechanical principles associated with the use of fixed appliances to achieve improvement in incisor alignment – but it is essential for the reader to recognize that responsible use of appliances demands meticulous diagnosis and treatment planning **before** embarking upon active treatment.

The beginner in the use of fixed appliances should be aware of the difficulties of treating certain incisor relationships. Particular points to consider are as follows.

Incisor angulation

Class II division 1 malocclusions with upper incisors at or near an ideal angulation, particularly where the overjet is 8 mm or more, should be approached with caution. If the aim is to achieve a Class I incisor relationship, the anchorage demands will be considerable. The orthodontist needs to be proficient in the management of the appliance before considering treatment. The patient must be prepared to co-operate in a fairly lengthy course of treatment which may well demand the use of extra-oral anchorage. Any treatment requiring movement of both crowns and roots in the same direction places heavy demands upon anchorage.

Class II division 2 cases are among the most difficult to treat because of the requirement, in severe cases, radically to change the interincisal relationship. Reduction of overbite can present a major problem.

In Class III cases, stability of incisor correction will demand a positive overbite. It is possible to increase the overbite by using vertical forces, but the degree of overbite obtained in this way is unlikely to be stable. Furthermore, vertical forces designed to extrude the incisors have been found to be associated with an increased risk of root resorption.

Skeletal pattern

The danger, in a marked skeletal Class II or III dental base relationship, is to concentrate on the achievement of ideal incisor angulation.

A Class I incisor relationship cannot realistically be achieved when there is a marked skeletal discrepancy. An approach involving skeletal surgery may be required in these cases if the best aesthetic and functional result is to be obtained.

Further reading

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14

Molar control

Although the control of molar teeth is part of the overall management of orthodontic treatment, there are several aspects which need special attention and discussion.

The alignment of misplaced molar teeth

Molar rotation

It is not uncommon to find that following the early loss of deciduous teeth the first permanent molars are misplaced. The upper molar tends to rotate mesiopalatally around the palatal root *whereas the lower molar tends to tip mesially* and roll lingually. Correction of molar rotation may be undertaken in a number of ways.

Plain archwires

The use of a plain archwire for the correction of mild to moderate molar rotations has been greatly helped by the availability of very flexible nickel-titanium wires because of their long range of action. Following the use of such archwires in the early stages, it will be possible to progress to a plain stainless steel archwire as the molar rotation is corrected. The use of a series of plain archwires of progressively larger diameter is recommended for the treatment of most molar rotations.

It may not always be possible to site the molar tube in its ideal position if the rotation is of a marked degree and in such cases the band, or bonded molar tube, may need to be removed and recemented as treatment progresses (Figure 9.11).

Modified archwires

The addition of horizontal bends in the plain archwire is useful to effect molar rotation or for their overcorrection (Figure 14.1). 'Toe-in' bends are used to produce mesiobuccal rotation, whereas 'toe-out' bends produce distobuccal rotation.

The amount of toe-in or toe-out depends upon the degree of rotation of the molar tooth. With a *0.016 in stainless steel archwire* a 20–30° horizontal bend is usually advised but a smaller degree of archwire activation will be needed with stiffer archwires. Care must be taken to control unwanted tooth movements, such as molar tipping, when using these second-order bends.

Before the development of archwires of low *stiffness and large range (e.g. nickel-titanium)* the use of a modified archwire was occasionally considered for the correction of molar rotations.

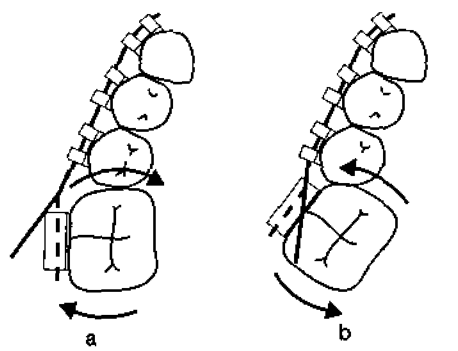


Figure 14.1 Archwire bends for the correction of molar rotation: (a) toe-out bend; (b) toe-in bend

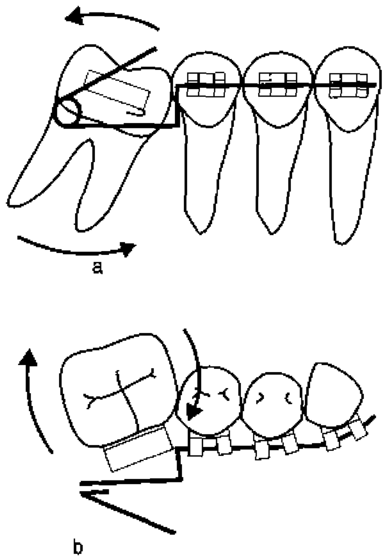


Figure 14.2 Modified archwire constructed to engage the molar tube from the distal aspect for: (a) uprighting, and (b) rotation. (Both shown activated, but without molar engagement)

This may still be of value where a severe molar rotation prevents insertion of the archwire into the mesial aspect of the molar tube (Figure 14.2). The archwire is so constructed as to enter the molar tube from the distal aspect and it is activated as shown to effect the molar rotation and, if needed, uprighting. These modified archwires may cause local soft tissue injury and are often difficult to construct. A plain archwire is used when the molar rotation has been corrected sufficiently to allow insertion of the archwire into the mesial aspect of the molar tube.

Extra-oral facebow

If extra-oral force is necessary for anchorage control then the ability of an extra-oral facebow to correct a molar rotation can be used to advantage for mild molar rotations. However, the use of the facebow inner arch to correct the molar rotation is difficult as the facebow is intrinsically rigid with a poor range of action. The facebow may also be difficult for the patient to insert. If used in this way, the inner bow of the facebow will need adjustment at each visit as the degree of molar rotation reduces. It may be necessary to correct a marked rotation using one of the other means described before the facebow can be inserted.

Palatal or lingual arches

The use of a palatal or lingual arch is another means of correcting molar rotations. Unlike the passive arches described in Chapter 8 which are recommended for molar anchorage purposes, the appliance used to correct a molar rotation will need to be an active arch. It is advisable to use a palatal arch which can be removed from the mouth without having to remove the molar bands at each visit. These removable palatal arches are attached to the molar bands by using palatal sheaths rather than a soldered joint. The attachments may have a vertical or horizontal path of insertion and the arch must be secured in place by using an elastic module or steel ligature to prevent its dislodgement between visits (Plate 21).

In order to introduce flexibility into the arch a number of modifications have been made. One of the more popular of these has been suggested by Ricketts and is known as the Quadhelix appliance (Plate 22). The Quadhelix appliance is used in a number of clinical situations including the correction of molar rotations, but most commonly for arch expansion. The arch is constructed from 0.9 mm diameter stainless steel wire or, as suggested by Ricketts, heat-treated cobalt chromium alloy – Elgiloy, which provides sufficient rigidity. The palatal arch incorporates four helixes which provide the flexibility needed. The appliance should be activated every five or six weeks. The removable form of Quadhelix has the advantage of being able to be activated outside the mouth without removal of the molar bands.

The use of a palatal arch for molar rotation should be considered when other tooth movements, such as arch expansion, is also required.

Elastics

Elastics may be used to produce molar rotation by attachment to a palatal button or cleat. The button can either be welded to the molar band, or directly bonded to the palatal surface of the tooth, if a molar band has not been used. Elastic thread or chain may then be attached to the buccal archwire. It is advisable to expand the upper archwire slightly in the molar region by about 5 mm to prevent the unwanted palatal movement of the molar tooth under the force of the elastic traction. The elastic may also be attached to a similar attachment on a premolar

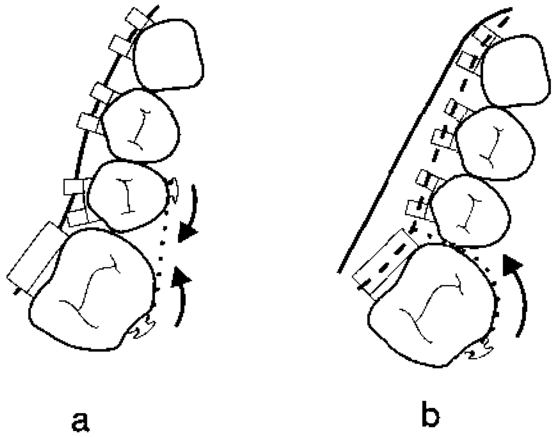


Figure 14.3 Correction of molar rotations: (a) using elastic chain to a button on the premolar; (b) using elastic chain or thread direct to the archwire. Note the expansion of the archwire to counteract the effect of the elastic on the arch width

tooth if the latter has a reciprocal rotation to correct (Figure 14.3).

Buccolingual movement – expansion

Plain archwires

An expanded labial archwire may be used to effect expansion of either upper or lower arches in order to correct a crossbite. The flexible archwires used in the initial stages of treatment will have little effect upon the arch form as they are rarely in place for more than a few visits. On the other hand, all archwires will increase the arch dimensions significantly if left in place in an expanded form over a considerable period of time. If a plain archwire is to be used it needs to be expanded in the canine **and** molar regions when in its passive form. The archwire should be constructed to fit the pretreatment arch form and then the labial curvature should be reduced as shown earlier in Figure 6.4. If the archwire is only expanded across the molar region it will tend to contract the intercanine distance when it is engaged in the molar tubes.

Close attention should be given to arch form during treatment and transverse relationships of the posterior teeth noted at each visit. It is quite easy to create a posterior crossbite during fixed appliance therapy if arch form dimensions are not monitored closely.

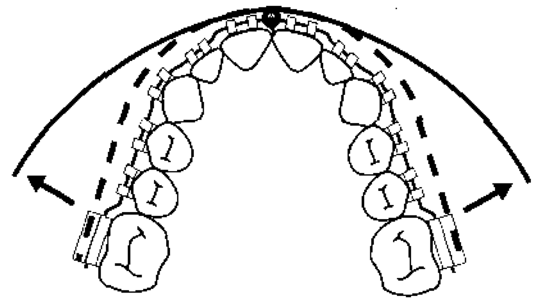


Figure 14.4 An auxiliary archwire to expand the upper arch. It is shown engaged in the headgear tube (dotted line), and is ligated to the main archwire in the midline

Auxiliary archwires

Arch expansion may be achieved by the attachment of an auxiliary archwire. The auxiliary archwire is constructed of 0.020 in stainless steel which is relatively rigid and can be inserted into either the auxiliary buccal tubes or into the headgear tubes on the molar bands. The archwire should be secured anteriorly using a steel ligature through the small helix in the midline to prevent its displacement in the mouth (Figure 14.4). This is a particularly effective form of arch expansion and requires close monitoring to avoid excessive molar movement.

Palatal and lingual arches

This particularly useful form of arch expansion has been covered earlier in this chapter. It is the recommended means of effecting arch expansion in most cases.

The Quadhelix appliance is a most effective means of expanding the upper arch to correct a posterior crossbite. A modified form of the appliance is occasionally used in the lower arch when only two helixes are incorporated. Provided the Quadhelix has been constructed as advised, expansion of the appliance of approximately 8–10 mm in total across the molars will provide the optimum force for arch expansion. The appliance can be reactivated after six weeks. Progress should be monitored by recording the arch width using dividers. This measurement can then be compared with the reference models. The appliance is also very useful for producing expansion in the premolar and canine regions. Correction of buccal segment crossbite using a Quadhelix is usually undertaken as the first stage of orthodontic treatment, often before the fitting of brackets to the remaining teeth.

The technique known as 'rapid maxillary expansion' (RME) is recommended by some orthodontists. The appliance most commonly used consists of a midline screw which is soldered to two molar bands and two premolar bands to form a rigid palatal fixed appliance. The screw is turned once or twice per day to effect a rapid expansion of the maxillary arch. It is usually undertaken in young children before the closure of the maxillary midline suture at about the age of 13 years. A review of the literature (Bell, 1982) has shown little advantage of this technique over the more conventional expansion with a Quad-helix, and there is some evidence to show that the latter may produce a more stable form of tooth movement.

Removable appliances

The main advantage of a removable appliance for arch expansion is the possibility of including posterior biteplanes to relieve occlusal interferences. However, screw plates impart strong and intermittent forces to the teeth and the screw will have a limited amount of expansion available. They are recommended by some orthodontists for the correction of unilateral posterior crossbites where a displacement of the mandible is present.

It is important to remember that the expansion mechanisms described above will apply an equal and opposite force across the arch and that close attention to the progress of treatment should be made to avoid unwanted tooth movements on the other side of the arch.

Posterior cross elastic

The use of a cross elastic is sometimes recommended for the correction of posterior crossbites at an early stage of treatment, or where the crossbite is limited just to the molar teeth and no other treatment is indicated. The opposing molars are banded and hooks or buttons, preferably two per band, are fitted lingually on the tooth which is displaced lingually and buccally on the opposing molar. These hooks are joined by a latex elastic ring, as small as the patient can manage, to offer a transverse force to the molars (Figure 14.5). Elastics worn double are very useful for this movement. The use of two attachments per tooth will limit unwanted tooth movements (such as molar tipping and rotation) which are sometimes seen while using this method of molar crossbite correction.

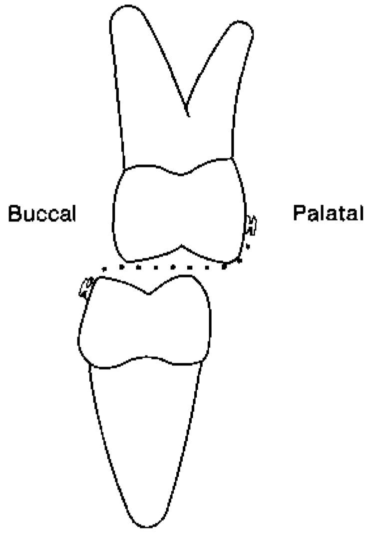


Figure 14.5 A cross elastic to correct a posterior molar crossbite

Contraction

It is less common to consider arch contraction as an aim of orthodontic treatment. Arch contraction is also quite difficult to achieve. Some localized lingual tooth movement will occur when using the posterior cross elastics described above. Removable appliances involving an 'open' screw can be used when the screw is turned in reverse to move the teeth palatally. Alternatively, plain archwires may be used in a contracted form.

Movements along the line of the arch

Distal movement

The distal movement of molar teeth has primarily been covered in Chapter 9. Because of anchorage requirements the distal movement of upper molars usually involves the use of extra-oral forces. Many removable and fixed appliance systems, even involving the use of magnets, have been advocated for the distal movement of molar teeth using intra-oral forces alone. However, it must be remembered that the force employed to move the molar teeth distally will produce an equal and opposite force tending to move the anchor teeth forwards. If this latter movement

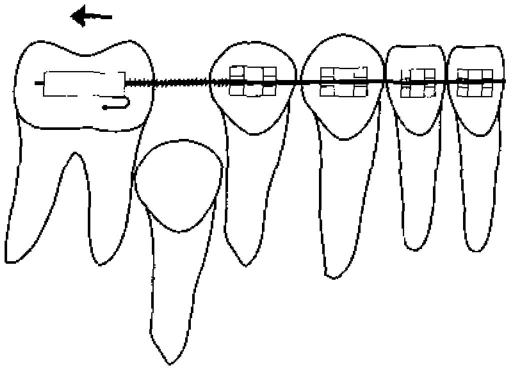


Figure 14.6 A compressed coilspring to move the lower first molar distally

is unfavourable then extra-oral forces will need to be employed.

Where only a small degree of distal movement is required, or a mesial movement of the anterior teeth can be tolerated to some degree, then intra-oral forces alone may be sufficient. An upper removable appliance incorporating a palatal spring to move the molar distally has the advantage of utilizing the anchorage available from the acrylic baseplate contacting the anterior vault of the palate. This method is useful if an upper molar tooth requires distal movement by tipping.

Distal movement of upper or lower molars may be carried out using a plain base archwire and a compressed coil spring (Figure 14.6). Nickel-titanium coil springs are useful in this respect. However, once again the effect of the coil spring on the anterior teeth (the anchorage unit) must be anticipated.

Bodily distal movement of lower molars, while theoretically possible, is difficult to achieve in practice. Various mechanics have been described including the use of headgear to the lower arch and lip bumpers (Chapters 8 and 9) but these have disadvantages. Wherever possible it is advisable to look for an alternative treatment plan that does not rely on the distal movement of lower molar teeth. While tipping movements may be possible the bodily translation of lower molar teeth in a distal direction is difficult to achieve.

Mesial movement

The mesial movement of upper molars may be brought about by the application of forces within the same arch – intramaxillary forces. Alternatively, class III intermaxillary forces may be used, utilizing the forces available from the lower arch. The use of protraction headgear (Plate 16) is a method of achieving mesial movement of upper molar teeth, where there is insufficient anchorage available intra-orally. In such cases, the protraction headgear should be worn preferably for 12–14 hours per day with an elastic force of 250 grams applied directly to each molar tooth. The direction of pull will tend to be downwards and forwards and this will have the effect of causing extrusion of the upper molars so reducing the overbite. The vertical component is an important feature of this type of space-closing mechanics and must be accounted for during the treatment planning stage. Protraction headgear is a useful method for the mesial movement of molar teeth, but it is not readily accepted by patients.

Lower molars may be moved mesially by intramaxillary forces or class II intermaxillary elastics.

Apical torque

The need for apical root torque to be introduced into the fixed appliance system is to compensate for the buccal convexity of individual teeth (Figure 14.7). Failure to establish the correct

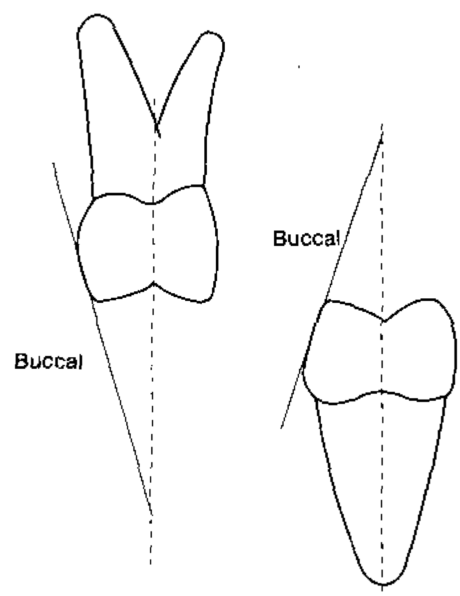


Figure 14.7 The buccal surface of both upper and lower molars is inclined relative to the vertical. The adjustments in the appliance to account for this are known as torque, or third-order bends

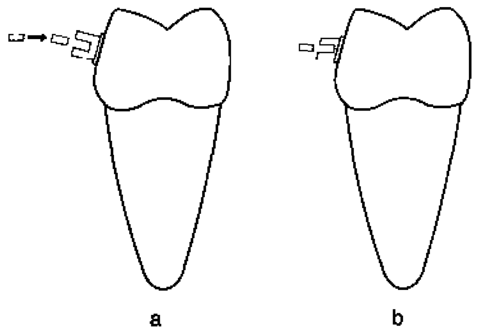


Figure 14.8 (a) The standard molar tube, shown here as an open bracket for clarity, has zero torque and so a third-order bend is needed in the archwire; (b) the pre-adjusted attachment has integral torque and a flat archwire may be used

apical position of the molar teeth would result in unfavourable cuspal contacts with the opposing molar tooth and occlusal interferences. Preadjusted molar tubes have a torque value built into the attachment itself but, dependent upon the dimensions of the archwire used, this will only be expressed to a limited extent. Standard molar attachments do not have any integral torque and this will need to be added to the archwire itself (Figure 14.8).

The torque in the lower buccal teeth increases the further back in the arch the tooth is – this is known as **progressive** root torque. It is introduced into a rectangular archwire using two torqueing pliers as follows.

1. Mark the archwire with a pencil mesial to the canine bracket.
2. Hold the archwire with the first pair of torqueing pliers on the pencil mark.
3. Using the second pair of torque pliers, hold the archwire at its most distal point (where it would emerge from the terminal molar tube) and twist the required degree of torque into the archwire. This will introduce a torqueing bend into the archwire that increases in extent the further back in the arch it is measured – progressive torque.
4. Repeat for the other side.
5. The degree of torqueing force introduced into the wire can be assessed by inserting it into the molar tube on one side and assessing how far below the molar tube on the other side it lies. It is easy to introduce excessive force and care must be taken.

In the upper arch the premolars and molars all require roughly the same degree of torque and this is known as **constant** root torque. This is introduced as follows.

1. Mark the archwire with a pencil mesial to the canine bracket.
2. Hold the archwire with one pair of torqueing pliers on the pencil mark.
3. Position a second pair of torqueing pliers as close to the first pair as possible, making sure the bend is to be made in an interbracket span of the wire. Holding both pairs of pliers, one in each hand, twist the archwire to introduce the torque. This will result in a degree of torque which will be the same for each tooth distal to the archwire bend – constant torque.
4. Check as described above.

Clearly if torque is required only in one molar tooth then the method suggested for producing constant torque should be used for that molar.

Some modifications in the Begg technique have been suggested to overcome the difficulty of trying to introduce torqueing forces into a system which relies upon round archwires in round molar tubes.

Molar extrusion and intrusion

The intentional extrusion of molars may be achieved by using vertical elastic loops between the maxillary and mandibular arches. These are usually attached to the molar hooks and are most commonly used in the final stages of treatment to achieve the maximum intercuspation of the posterior teeth. Individual molars may be intruded or extruded to a limited extent by using vertical offsets (Figure 14.9).

True intrusion of molar teeth is particularly difficult to achieve and there is little firm evidence to show that true intrusion occurs. More commonly, there is a restriction of the molars' vertical development. The use of an upper removable appliance with high-pull headgear, or fixed or removable occlusal platforms, have been described for such cases.

Uprighting molars

It is commonly the lower molar teeth which tip mesially during their forward movement and as a consequence they often require uprighting. Simple distal movement by tipping may be undertaken using a flexible archwire as described

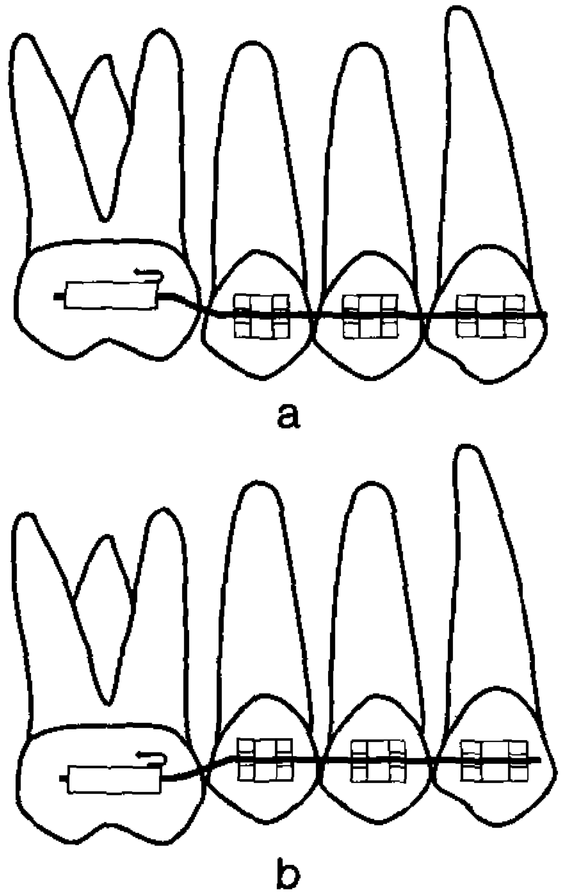


Figure 14.9 Vertical offsets to: (a) intrude, and (b) extrude the first molars

for the correction of molar rotation. In a more severe situation the use of a modified archwire may be considered (Figure 14.2).

When uprighting molar teeth, consideration should be given to the anteroposterior position of the molar crown. If additional space is required in the lower arch then the molar should be allowed to tip distally as it is uprighted. Alternatively, if there is excessive space within the arch, distal tipping of the tooth should be prevented. This can be undertaken by ligating the molar to the anterior teeth.

Treatment of impacted molars

Impacted upper molars

Occasionally an upper first permanent molar tooth will fail to erupt fully due to its impaction against the distal aspect of the second deciduous molar. In mild cases, the impaction may correct itself spontaneously. Alternatively, separation of the teeth using an elastomeric ring, a length of 0.5 mm soft brass wire or a wire separating spring may be of assistance if the impaction contact point is superficial enough for direct access to be possible.

In more severe cases the extraction of the deciduous tooth may have to be considered. The permanent molar can then be uprighted and moved distally following further eruption. If disimpaction is to be attempted then distal tipping of the molar tooth must be undertaken before movement in an occlusal direction may be attempted. This is best achieved by bonding a button onto the occlusal surface of the impacted tooth and using a removable appliance spring to move the molar tooth distally. As the impacted molar will not be fully erupted, there is usually space for the attachment to be bonded onto the occlusal surface without contact with the lower molar. If this is not the case then the attachment will need to be sited on the buccal or palatal surface but this will make the spring less effective. The spring may be part of an upper removable appliance but insertion by the patient may prove difficult (Plate 23). Once the impaction has been freed the tooth can be uprighted by more conventional fixed appliance methods.

Impacted lower molars

Lower molars, usually the second molars, may require active orthodontic intervention to free their impaction. Various mechanisms are available to effect such tooth movements and these include those suggested for the management of upper first molars and the looped archwires described for molar rotations.

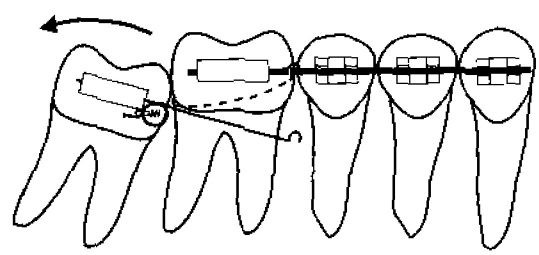


Figure 14.10 A whip spring to upright the lower second molar. The solid line shows the spring before attachment to the main archwire. The helix in the spring is ligated to the molar hook to prevent dislodgement

Another possible fixed appliance mechanism is the use of a whip spring (Figure 14.10). In this situation it is unlikely that a molar band would be able to be fitted onto the impacted tooth and a directly bonded buccal tube should be used. A small sectional archwire can then be placed into the buccal tube of the lower second molar.

The whip spring can be constructed from round wire but if it needs to be cranked then rectangular wire will be needed to prevent rotation of the accessory. It is advisable to secure this whip spring in place, using an elastic or steel ligature tied through the helix in the spring to the molar hook. The whip spring is then lifted into position and is hooked on to the archwire. This mechanism imparts a distally directed and extrusive tipping force to the molar tooth to free the impaction.

If a large degree of uprighting is needed the use of a lingual arch attached to the first molar bands is recommended to prevent unwanted movements of the teeth used for anchorage. Once the molar is sufficiently uprighted, a flexible continuous archwire can be substituted for the whip spring.

Prevention of unwanted molar tooth movements

Mesial movement

Molar teeth have a natural tendency to undergo forward drifting and will readily move mesially. Prevention of forward movement of the upper molars is often required and primarily involves the use of headgear or a palatal arch. The forward movement of lower molars is more difficult to prevent but the use of lingual arches and anchorage bends may be considered.

Rotation and tipping

Upper molars have a tendency to rotate mesially about their palatal roots whereas the lower molars tend to move mesially by tipping and rolling lingually. Palatal and lingual arches will restrict these movements. An acrylic button can be incorporated into the anterior section of the palatal arch and its use is recommended by some clinicians to dissipate the forces over a wider area and offer more resistance to the mesial tipping of the molars. However, oral hygiene may be a problem and soft tissue trauma can occur under the palatal button if excessive demands are placed on the anchorage from the molars. Alternatively a transpalatal arch may be used as an effective means of combining the molars to increase their anchorage value (Figure 8.12). A palatal or lingual arch restricts the mesial movement of the molars by reducing their freedom to rotate or tip.

Archwire form

The use of toe-in and tip-back bends are important in preventing loss of molar control (Figure 14.11). These have been described earlier in this chapter. A toe-in bend will reduce the tendency for molar rotation whereas a tip-back or anchorage bend will restrict the molar tooth's natural tendency to tip during its mesial movement.

Elastic traction

It is an important principle not to apply elastic traction to molar teeth before the archwire is sufficiently rigid to allow adequate molar control. The lightest archwire recommended for commencement of intra- or intermaxillary traction would be 0.016 in round stainless steel. The use of elastic traction applied to molar teeth on an insufficiently rigid archwire will result in unwanted molar tipping, rotation and extrusion.

Elastic traction is best applied to a molar hook which is sited on the mesiobuccal aspect of the molar tube. The attachment of the elastic from the archwire as it emerges from the distal aspect of the molar tube will tend to encourage molar rotation and tipping (Figure 14.12).

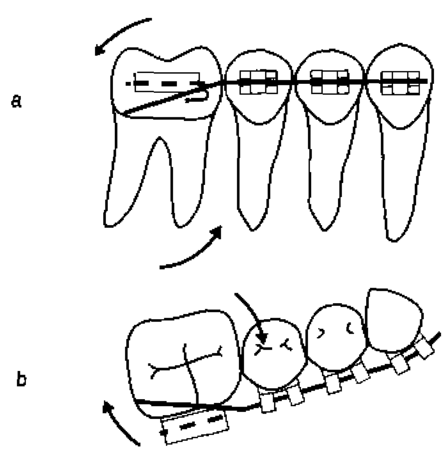
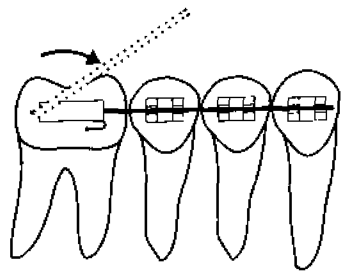


Figure 14.11 (a) Tip-back bend; (b) toe-in bend

a



b

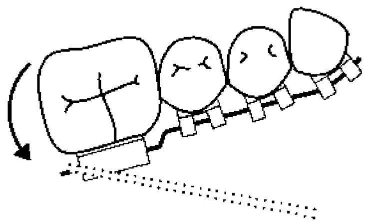


Figure 14.12 Application of the intermaxillary elastic to the archwire distal to the molar tube will result in: (a) molar tipping, and (b) rotation

In the lower arch, the use of mesiolingual buttons or hooks can be used for the application of class II traction. This has the combined effect of pulling the mesiolingual aspect of the tooth buccally and vertically thus preventing both rotation and tipping of the tooth. The use of these lingual buttons is particularly useful for the application of class II elastics in the Begg technique.

Expansion and contraction

Both the maxillary and mandibular arches naturally diverge distally. Any distal movement of the molar teeth must involve some form of expansion of intermolar width. Failure to expand the intermolar width as the upper molars move posteriorly would move the teeth into a crossbite relationship with the lower arch.

Class II intermaxillary elastic traction from the buccal aspect of the lower molars will have a tendency to roll the lower molars lingually and so reduce the intermolar width. In order to counteract this narrowing the lower archwire should be expanded in the lower molar region by approximately 5 mm.

Conversely the fitting of an archwire with considerable torqueing action to the teeth in the upper labial segment (such as a 0.021×0.025 in rectangular archwire, or a torqueing auxiliary archwire in the Begg technique) will tend to expand the teeth posteriorly. To overcome this expansion such archwires should incorporate contraction of the arch form across the intermolar width in order to prevent expansion as torqueing proceeds in the upper labial segments. Once again, it is stressed that it is very difficult to contract an archform that has been inadvertently expanded during treatment – it is certainly easier to prevent it and therefore careful observation of the molar position and comparison with the reference models is needed throughout treatment.

First molar extractions

The extraction of the permanent first molar teeth is rarely desirable for purely orthodontic reasons. However, where the extraction of permanent teeth is required to provide space for the relief of crowding, the prognosis of the first permanent molars may dictate their extraction.

If the extraction of the first permanent molars is undertaken at the optimum developmental time, significant spontaneous alignment may occur. However, once the second molar teeth have started to erupt into the mouth, the extraction of the first molars will result in much less spontaneous favourable tooth movement, especially in the lower arch. Fixed appliances are inevitably needed for the control of the second molar position and space closure.

Following the late extraction of first molars in the lower arch, the second molars often tip lingually and rotate forward. Unfortunately, there is little spontaneous relief of lower incisor crowding and the final relationship between the second molar and second premolar is usually unsatisfactory. In the upper arch the second molars move forward to a greater extent than in the lower arch but usually rotate mesiopalatally.

Many malocclusions which could otherwise be treated relatively simply are complicated by enforced loss of the lower first molars and may require a fixed appliance as a result.

Forward movement of lower second molars

Lower second molars – initial alignment

Controlled forward movement of lower second molars is not easily achieved. When the lower second molars are tilted mesially and lingually following the extraction of lower first molars, the

initial aim of treatment is to upright the teeth and then to move them forward bodily.

A plain flexible archwire is used to commence correction of the mesiolingual inclination. This archwire should be expanded across the intermolar distance by at least 10 mm to overcome the tendency for the molars to roll lingually. When there is space mesial to the molar, as is often the case, the second molars should be ligated forwards to the canine teeth. This will restrict distal tipping and allow uprighting to occur primarily by mesial movement of the root. This will reduce the time spent on space closure later.

Lower second molars – mesial movement

Mesial movement of the lower second molars is best achieved by using a combination of inter- and intramaxillary traction. The archwire is made of at least 0.016 in diameter stainless steel wire, and expanded across the intermolar width. The use of rectangular wire is recommended as this will afford greater molar control in all three dimensions. The molars slide along the archwire under the influence of the traction which is applied. Patience must be exercised in the uprighting and the mesial movement of lower second molars.

Class II intermaxillary traction elastics can be attached to mesiolingual hooks on the lower second molar bands, so helping to correct lingual or mesial inclination of these teeth. Intramaxillary traction can be applied by elastic or coil springs. Elastics are attached mesially to archwire hooks in front of the lower canines, and distally to mesiobuccal hooks on the molar bands. Intramaxillary traction can be applied simultaneously to the lingual and buccal aspects of the molar tooth to permit controlled mesial movement.

As an alternative to the sliding mechanics described above, closing loops can be placed in the buccal sections of the archwire to apply frictionless intramaxillary traction. They have the disadvantage of increasing the flexibility of the distal part of the archwire so that a certain amount of control over the molar is lost. If constructed in round wire, when activated they can rotate out of their intended position and cause irritation to neighbouring soft tissues.

Lower second molars – detailing

When the second molars have been brought forward into contact with the second premolars, a final archwire is required to produce uprighting, as the teeth will always tip to some degree. A stainless steel archwire of 0.016 in diameter with anchorage bends may be used initially as it will have a greater range of action than a rectangular archwire. Toe-in bends may also be necessary to correct rotation. The archwire can be activated progressively, but it is most important that the molar crown is prevented from moving distally. In order to prevent distal movement of the molar, the archwire can be turned down hard as it emerges from the molar tube, or a long ligature used to tie the molar forwards – the latter method is preferable. Slight over-treatment, with elevation of the mesial marginal ridge of the molar, is desirable.

Some thought also needs to be given to the extraction site. If the extraction sites are of long standing, or a traumatic extraction has resulted in the loss of lingual or buccal alveolar bone, 'necking or waisting' of the alveolus may have occurred. It is still possible to move teeth into such a narrow area of bone but as the proportion of cancellous bone will be reduced, tooth movement is slower to achieve. There is also some evidence that maintenance of space closure may be difficult in such cases with an increased likelihood of the space reopening. In addition, there may be periodontal disadvantages to moving teeth into an area of reduced alveolar bone height.

Upper second molars

Initial alignment of upper second molars is primarily concerned with their rotation. The mechanisms for this have already been discussed. If additional space is needed in the upper arch it is best to allow the upper second molar to rotate distally. In such cases, the second molars should not be ligated forwards and the archwire should not be turned down hard as it emerges from the distal aspect of the molar tube.

The forward movement of the upper second molars is not as difficult to accomplish as forward movement of the lower second molars. A satisfactory contact point between the second molar and second premolar may be established spontaneously without the need for appliances because upper second molars rotate forward, whereas the lowers tend to tip. As a consequence of this the problem in the upper arch is often

one of anchorage control and the prevention of excessive space loss.

The difficulty of providing sufficient anchorage commonly arises when the space provided by the extraction of upper first molars is required both for the alignment of teeth and reduction of an overjet. If extra-oral force is required it can be applied by means of a facebow fitted to the second molar bands. Unfortunately, it may be difficult to make upper second molar bands retentive enough to withstand the extra-oral forces. An alternative is to apply the extra-oral force directly to the archwire at the front of the mouth. If extra-oral force is applied to the front of the archwire, stops must be placed in front of the second molars to deliver the force directly to the molars.

Rotation and tipping of upper second molars is not such a complication of forward movement as it is in the lower arch. Toe-in and uprighting bends may be used if necessary but these are usually not needed until the final archwires are made.

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15

Finishing procedures

Having corrected the main features of the patient's malocclusion, the operator can begin to address detailing of the occlusion. Before completion of active treatment there are a number of finishing procedures to be considered. This chapter will cover these final tooth movements, the removal of the appliances and the subject of retention.

The surgical procedures undertaken to reduce the possibility of unwanted tooth movements occurring following removal of the appliances will also be covered.

Detailing of the occlusion

Final tooth movements undertaken prior to removal of the appliances are referred to as detailing of the occlusion. A number of tooth movements should be considered.

Root parallelling

Following space closure, the teeth adjacent to the spaces will have been tipped towards one another (Figure 15.1(a)). To reduce the possibility of the spaces re-opening following removal of the appliances, it is important to correct these tooth inclinations by uprighting the teeth which have been approximated. While this will not guarantee that the spaces will remain closed, root parallelling may reduce the tendency and will assist in the establishment of good buccal intercuspation. The use of wide brackets, such as Siamese edgewise, will reduce unwanted tooth tipping during space closure, but a certain amount of tipping inevitably occurs.

Root parallelling usually involves the construction of an active archwire designed to move the roots of the teeth together (Figure 15.1(b)); such bends are often referred to as 'gable bends'. It may be advantageous to change to a more flexible archwire than that used for space closure, although this is not essential if the movements required are small. Care is required to avoid unwanted tooth movements. The archwire should

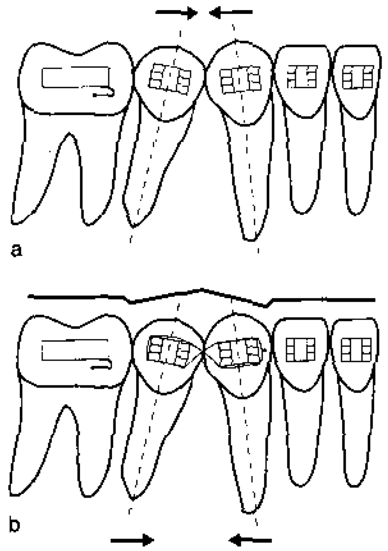

Figure 15.1 *(a) A canine and premolar tooth, tipped together following space closure;* (b) the archwire designed to upright the teeth using 'gable bends'; note the ligation of the teeth together

be active only in the brackets of teeth that require uprighting. The absence of active forces in the adjacent teeth is practically impossible to achieve, but certainly an attention to detail is needed. It is important to ensure correct arch form at this stage. The archwire shown in Figure 15.1(b), will tend to move the crowns of the teeth apart and this must be prevented by tying the two teeth together with a steel ligature.

As with other features of the malocclusion, it is a good principle to overcorrect the apical position slightly, as there is usually a tendency for the spaces to reopen after removal of the appliance. The closure of a maxillary midline diastema, or extraction spaces in an adult patient, are examples of situations where there appears to be a particularly high potential for the spaces to re-open. However, some clinicians feel the most suitable treatment for diastema closure is not to overcorrect root position but to bond a fixed retainer where possible.

The Begg appliance system, and its derivatives, relies upon the use of auxiliary uprighting springs, rather than bends in the archwire, to achieve root parallelling. It is extremely difficult to retain the tooth rigidly at the correct angulation when that type of bracket is in use, although light forces acting over a large range can be used to produce the active uprighting. The principles employed with the Begg appliance are similar to the edgewise, in that a force couple is applied to the crowns of the teeth to produce the required apical movement, and crown separation should be prevented. In the Begg technique, root uprighting may form a considerable part of the total treatment time and it is often best to warn the patient in advance that the treatment is not complete once the spaces have been closed.

Root torqueing

Root torqueing may well have been completed before the finishing stages of treatment are reached. However, some further torqueing movements may need to be undertaken to achieve the treatment goals, even when a preadjusted appliance system has been used with torque built into the brackets. Torqueing movements may, for example, require the palatal movement of upper incisor roots following the reduction of an increased overjet, or the buccal root torqueing of premolar and molar roots after the correction of a posterior crossbite by expansion. Full thickness wires of 0.021 × 0.025 in archwires in a 0.022 in bracket slot may be used to achieve such tooth movements. As stainless steel archwires in such dimensions are very rigid, many operators prefer to use a more flexible Beta-titanium archwire (TMA) to deliver the final torque forces to the teeth. The Begg appliance relies on auxiliary wires to produce torqueing forces and, once again, light forces can be applied over a long range of action.

Torqueing forces may be incorporated into a rectangular archwire either by using a pair of torqueing pliers or keys.

Rotational overcorrection

Certain tooth movements have been found to be liable to relapse despite prolonged retention. Rotational correction, diastema closure and apical movement are notable in this connection. It has been suggested that if these movements are overcorrected and the teeth then retained in that position for an extended period (at least six months, although there is no agreement over this time period), relapse to the initial tooth position may be less likely to occur. As with the parallelling of teeth following space closure, the overcorrection of rotations will require the bending of the archwire to bring about the desired tooth movement. Unfortunately, rotational overcorrection does not guarantee success and the tooth may remain in its over-treated position. The best solution may be to correct the rotation and advise permanent retention of the tooth in its ideal position.

Overcorrection bends are also required if the operator wishes to overcorrect incisor labio-lingual displacements, once crowding has been relieved (Figure 15.2), although these may be difficult to achieve if the incisors are in a Class I relationship.

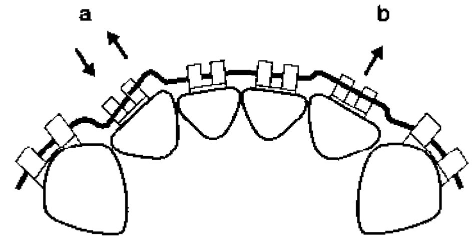

Figure 15.2 Archwire bends for: (a) rotational overcorrection and, (b) overcorrection of lingual displacement

Pericision

Reitan (1958) suggested that the free gingival and trans-septal fibres of the periodontal ligament are causative agents in the relapse of rotated teeth. The relatively minor surgical procedure known as pericision is concerned with sectioning these fibres. Under local anaesthetic, a fine scalpel blade is used to separate the free gingival and trans-septal fibres from the rotated tooth. The blade is inserted through the gingival crevice parallel to the long axis of the tooth in an apical direction. Care should be taken to ensure that the blade is taken completely round the neck of the tooth to the depth of the alveolar bone crest. There is no evidence to suggest that there is any permanent damage to periodontal tissues following this procedure.

It is recommended that when pericision has been undertaken, the teeth involved should be retained for six months before the appliance is removed. The pericision should be carried out as soon as the rotation has been corrected, ideally at the end of the initial alignment stage, and should not wait until the appliances are due to be removed. In this way the rotation would be retained with the fixed appliance throughout the remainder of the treatment. It must be emphasized that removable appliances are incapable of adequate control over tooth position following rotational correction.

Pericision of a tooth does not guarantee a stable tooth position and there is some evidence to suggest that it may be of less value in the long term.

Fraenectomy

The surgical removal of the maxillary labial fraenum is recommended by some clinicians in an attempt to prevent the re-opening of a maxillary midline diastema following space closure. There is little firm evidence to show that this is effective and there is indeed some evidence to show that it has little long-term benefit. If it is to be undertaken, most advocates would suggest that it is performed after the closure of the space, rather than before it, as the resultant scar tissue is thought to interfere with space closure.

The gingival recontouring of the fraenum to improve access for toothbrushing or for aesthetic purposes may be recommended but this is a separate surgical procedure, known as gingivoplasty, and is undertaken for a different purpose.

Occlusal finishing

Before removal of the appliances it is important to take a close look at the intercuspation of the teeth. This should have been monitored throughout the treatment period, as the buccal relationship is a most useful guide to the management of the available anchorage. Ideally a good intercuspation of the teeth will already exist but some detailing of the buccal occlusion at the end of active orthodontic treatment will usually be required. This is best carried out by returning to light wires (0.016 in) and using short vertical elastics to Kobayashi hooks in both arches. If the occlusion is slightly pre- or postnormal then an anteroposterior element should be introduced into the elastic forces. Anterior cross elastics may also be needed for the adjustment or overcorrection of any centre-line discrepancy. If fixed appliances have only been used in one arch the potential for achieving a good intercuspation of the teeth will be much reduced.

In addition to the static occlusion, the operator is responsible for production of an occlusion that is free from occlusal interferences in function. It is important to check the occlusion in protrusive and lateral excursions throughout treatment and not merely at the end. The occlusion should be examined for occlusal interferences as well as checking for any marked discrepancy between the intercuspal position (ICP) and the retruded contact position (RCP). It is emphasized that while, for convenience, this is mentioned under finishing procedures, the principle of the functional aspects of the occlusion is important and one which requires attention throughout treatment and not just prior to its completion.

The orthodontist should have specific aims for the occlusal end result:

1. As many teeth in occlusion as possible (this may be limited for example by the skeletal relationship).
2. A relationship which avoids the generation of displacing forces when the teeth are brought together into the intercuspal position. Displacing forces may lead to tooth movement and this may lead to orthodontic relapse.
3. A relationship which minimizes non-axial loading of opposing teeth, because this can lead to a traumatic interdental relationship.
4. A relationship which avoids contact between the incisors and the gingival margin of the opposing arch – a traumatic overbite.

5. An occlusion free from occlusal interferences in all excursions of the mandible. These can be found as non-working side interferences and may often be caused by inadequate molar root torque as the palatal cusps of the maxillary molars are below the occlusal plane. Maxillary second molars may need to be included in the appliance if this is found.
6. Although many individuals possess a symptomless occlusion in which there is a discrepancy between ICP and RCP, it is preferable to establish the occlusion in such a way that the two coincide. To finish treatment with a mandibular displacement is not good occlusal management. The occlusion needs monitoring during treatment as patients will often find a comfortable intercuspal position during treatment as the buccal occlusion is changing. Ensure that there is not an ICP/RCP discrepancy before removal of the appliances.

Removal of the appliances

Band removal

Care is needed during the removal of the orthodontic appliance to avoid damage to the soft tissues and to the teeth. Extreme care should be taken with heavily restored teeth, crowned teeth, mobile teeth or teeth with small roots such as lower incisors.

Molar bands should be removed using a pair of band-removing pliers. It is best to place the pliers on the aspect of the tooth which has minimal undercut. Therefore, upper molar bands should be removed from the palatal aspect and lower bands from the buccal. Bands are best removed with a squeezing action of the pliers, rather than tipping, which is less efficient.

Bands which prove particularly difficult to remove can be split using a pair of band-splitting pliers.

Bracket removal

The removal of bonded attachments requires patience and care. Stainless steel brackets can be removed in a number of ways:

1. Bond-removing pliers, with hardened cutting edges which fit between the enamel surface and the bonding base, may be used. The pliers exert a force at right angles to the tooth surface. Twisting forces may cause separation of the enamel from the dentine, and are best avoided.
2. Bond-removing pliers tend to cause the patient some discomfort. The introduction of the 'lift-off plier' (Plate 24) has eliminated much of the discomfort from debonding. This instrument is supplied with a small tool of either 0.018 in or 0.022 in dimension to place in the bracket slot to prevent distortion of the archwire channel during appliance removal.
3. Siamese brackets may also be removed by using a pair of Adams universal pliers or an old pair of ligature cutters and squeezing the bracket across the tiewings. This has the effect of distorting the bracket base, so breaking the cement seal. This may be particularly useful for mobile or sensitive teeth.

It may be advisable to remove the whole appliance: bands, brackets and archwire, in one piece without removing the archwire first. This should prevent any small pieces of the appliance from becoming detached in the mouth and being inhaled or swallowed.

The removal of ceramic brackets is less straightforward, although at the time of writing the situation has greatly improved with the advent of mechanical bonding bases rather than the chemically bonded, first-generation brackets. Some manufacturers recommend the use of a bracket-removing key which is used with a twisting action, while others suggest the use of various designs of bracket-removing pliers. It is certainly advisable to follow the manufacturer's recommendations for the removal of brackets and to record in the patient's notes the type of brackets fitted and how they should be removed at the end of treatment. The reader is referred to the article by Winchester (1992) for more information on the removal of ceramic brackets.

When removing orthodontic brackets, a varying degree of composite adhesive will be left on the tooth surface. This residual composite can be removed by a number of methods:

1. The adhesive can be flaked away using a push scaler or a Mitchell's trimmer, but some operators feel this may damage the enamel.
2. Specially designed tungsten carbide burs may be used to remove the residue of adhesive or alternatively an ultra-sonic scaler may be used. It is felt that removal of the adhesive by rotary instruments causes less enamel damage than if hand instruments are used.

3. Small remnants may be removed using a series of polishing discs.

Whichever method is used, damage to the tooth surface must be kept to a minimum. The debonding process can be particularly uncomfortable for the patient, and occasionally it may be advisable to delay complete removal of the adhesive until an appointment after bracket removal. Glass ionomer cement is much easier to remove than composite resin and this is one of the advantages of this adhesive.

After band and bracket removal, the teeth should be scaled and polished to remove any remnants of cement and adhesive adhering to the tooth surface. A thorough examination for carious cavities should then be undertaken and arrangements made for any necessary conservation work to be carried out. It is a good idea for the patient to continue using a fluoride rinse throughout the retention period. If any decalcification has occurred it should be noted, explained to the patient or parent and the exposure of the lesion to a daily low dose fluoride rinse is preferable to the application of a fluoride varnish. The latter will prevent the penetration of fluoride ions into the deeper areas of the lesion.

Retention

Retention should be regarded as an **integral part of treatment** – it should be planned and explained from the start. The understanding of just how much retention is required is unclear and it must be emphasized that it is not possible to guarantee the stability of **any** tooth position once the retaining appliances have been removed. It is misleading to undertake orthodontic treatment implying that teeth will remain in their achieved positions forever. It is also wrong to think that if they can be held in position until the majority of facial growth is complete and the third molars have been removed, then stability can be guaranteed. This is not the case. As discussed in Chapter 1, long term studies have shown that tooth movement is a normal physiological phenomenon, whether orthodontic treatment has been carried out or not, and that these movements have been shown to continue throughout life. The arch dimensions tend to reduce and, as a consequence, crowding usually increases with age.

However, in many cases a lasting and significant degree of improvement can be achieved, and it is certainly not wise to remove the appliances as soon as tooth movement is completed because then the risk of significant and rapid relapse is greater. The causes of such relapse are often difficult to identify because the factors which determine stability are not easily quantified.

The form and behaviour of the surrounding soft tissues are certainly an important factor. If the teeth have been moved into positions in which they are subjected to muscular forces which are not in balance the teeth will move under the influence of the applied forces. It would appear that there is a threshold of force which the periodontal tissues can withstand and it is only when this threshold is exceeded that the tooth becomes unstable.

It is pointless to move teeth into a position of extreme muscular imbalance and retain them, hoping that no relapse will occur when the appliance is finally removed. It could be argued that if the teeth have been moved into a position of balance with regard to environmental forces, no retention whatsoever is required. The problem however is that it is impossible to define with accuracy the direction or magnitude of the local environmental forces, and they are likely to change as the patient grows older.

Occlusal factors, which again are difficult to measure, are important in determining tooth stability. If, when the teeth are in occlusion, opposing cuspal inclines relate in such a way that displacing forces are generated, an alteration of tooth position may occur. Ideally, at the completion of tooth movement, the manner in which the upper teeth relate to the lower teeth in occlusion should not cause displacing forces to be delivered to teeth in either arch.

Duration of retention

The duration of retention may be described as being either: standard, prolonged or permanent. Standard retention consists of three to six months of full-time wear of a removable retainer followed by three to six months of part-time wear – usually night-time wear only.

As previously discussed, certain tooth movements, such as diastema closure and the correction of severe rotations, require prolonged or even permanent retention.

Permanent retention is reserved for those malocclusions where the tooth movements are almost certain to be unstable. The treatment

of patients with advanced periodontal disease would certainly be in this group. Permanent retention, either with fixed retainers or the wearing of removable retainers on a regular but part-time basis, is also reserved for those patients who require a guarantee of the stability of tooth position. However, the retainers will not last indefinitely and regular monitoring of them will be required.

Methods of retention

Archwires for retention

Following the completion of active treatment the fixed appliance may be used for retention. Specific sections of the appliance, such as in the lower labial segment, may be left in place to act as a retainer, after the removal of the rest of the appliance. The function of the archwire during the period of retention is to hold the teeth rigidly in the position into which they have been moved. Ideally rectangular archwires should be used to retain tooth positions in three dimensions but thick (0.018 or 0.020 in) round archwires may be suitable in some cases. Because of the relative inflexibility of these archwires they must be very carefully prepared in order to prevent inadvertent tooth movement during the period of retention. Full bracket engagement must be possible without distorting the archwire from its passive form. The teeth are then ligated tightly to the archwire.

Archwire offsets are used to retain overcorrection of rotational and apical position. When a space between two teeth has been closed, reopening of the space during the period of retention can be prevented by tying the teeth together with a steel ligature. If an overjet has been reduced, proclination of the upper incisors can be prevented by turning the end of the upper archwire upwards hard against the distal end of the molar tube, or by tying the archwire back to the molars with long ligatures.

Removable retainers

Removable appliances are frequently used to retain tooth position following fixed appliance treatment. They are routinely used for standard retention but also occasionally for prolonged or indeed permanent retention. However, it is not possible to retain apical or rotational position rigidly with removable appliances. The standard Hawley retainer with clasps on first molars and a labial bow is commonly used in either arch.

If first premolars have been extracted it is advisable to solder the labial bow to the bridges of the clasps to avoid the labial bow reopening the extraction spaces if it is brought across the occlusion distal to the canines. In addition, if there is full intercuspation in the buccal segments then it is advisable not to extend the wirework of the retainer across the occlusion and a Begg or wrap-around retainer may be used. The addition of an acrylic overlay to the labial section enhances the ability of the appliance to retain tooth position precisely (Plate 25).

Removable retaining appliances have the advantage that they can be slowly discarded over a period of time, so allowing the occlusion to 'settle' to a certain extent during the period of part-time retention. However, it is preferable to treat all features of the malocclusion before removal of the appliances as it is not wise to expect all settling movements to be favourable.

There is often a need for a removable retainer which has a prosthetic tooth present to hold a space open prior to the construction of a partial denture or bridgework. In such cases, it is advisable to place a metal stop on each side of the space to prevent the adjacent teeth from moving, especially if the prosthetic tooth were to fracture away from the retainer. If a bonded retainer or adhesive bridgework is to be placed, the inclusion of an anterior bite plane on the retainer may also produce the small amount of bite opening required to fit the metalwork of the retainer or bridge on the abutment teeth.

Vacuum formed removable retainers are used by some operators. Although these have the advantage of being quick and simple to produce they cannot easily be adjusted, should small tooth movements be needed in retention and the occlusion cannot settle effectively.

Tooth positioners

Tooth positioners are flexible one-piece soft plastic appliances which fit over the crowns of the teeth in both upper and lower arches. They may be used as retaining appliances, and may also be constructed in such a way as to produce a limited amount of tooth movement. Tooth positioners are usually prepared on models taken at bracket removal where necessary, teeth are sectioned from the models with their position altered slightly before the positioner is made.

Fixed retainers

These are used primarily for prolonged and permanent retention and may be either bonded in place or, less commonly, cemented by soldering the retainer to orthodontic bands. Preformed bonded retainers are available in a range of sizes for two or more teeth and are bonded in place using composite resin.

Alternatively, laboratory constructed retainers can be fitted and these may either be of a simple construction of wire and acrylic or a more complex cast metal framework similar to that used with adhesive bridgework.

The fixed retainers discussed above have the disadvantage of holding the teeth in a rigid position so limiting their physiological movements during function. The long-term effects of this is unknown as yet but an added problem with the rigid fixed retainers is the increased risk of breakage of the retainer or failure of its adhesion to the teeth during function. To overcome this, the use of flexible spiral wire retainers has been suggested. A length of multistrand wire of 0.0175, 0.0195 or 0.0215 in is adapted to the teeth. This can be difficult to fabricate and the use of a study cast will make this easier. The wire is secured in position on the teeth with composite resin which is then shaped and polished. The use of a light-cure system may help in the fitting of these retainers.

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16

Chairside management

Orthodontic treatment requires careful attention to detail in order to obtain precise positioning of the teeth and to achieve the treatment goals.

It has already been stressed that fixed appliances are complex mechanisms which require understanding and competence to manage correctly. Several tooth movements may be occurring simultaneously and only by continuous assessment can efficient and effective treatment be achieved.

Before commencing treatment, it is essential to have a treatment plan with clearly defined objectives. At each visit a careful check will need to be made to ensure these objectives are being met within the anticipated time scale.

Orthodontic treatment may take two years to complete. It is necessary continually to identify the changes that are occurring and take appropriate action. Changes can only be assessed by comparison with the reference models of the original malocclusion.

Commencement of treatment

Objectives and records

Before starting treatment, the following should be discussed with the patient in detail:

- aims of treatment;
- expected treatment time;
- frequency of appointments;
- required standard of oral hygiene.

New records are indicated if there has been some time interval since the diagnostic records were taken. However, in order to minimize radiographic exposure, repeat radiographs should only be taken if the treatment plan may be altered significantly due to possible new findings.

Clinical photographic records are of great value. They will provide a permanent record of the original malocclusion and of any dental imperfections that may be present at the start of treatment. Hypoplastic areas, decalcification, fractures and restorations are recorded. It is important to identify these variations before commencing treatment rather than dispute their presence and cause when the fixed appliances are removed. It should be remembered that damage to teeth may occur during orthodontic treatment. The operator must be able to distinguish between a pre-existing imperfection and damage associated with treatment.

Measurement

Base line measurements should be taken, and recorded in the patient's notes prior to the placement of appliances or extraction of teeth. These measurements, used in conjunction with the reference models, will allow tooth movement which takes place during treatment to be assessed.

The following points should be recorded:

- intercanine and intermolar width in both arches;
- canine to molar distance in both arches;
- overjet, overbite and centre lines;
- molar and canine relationship.

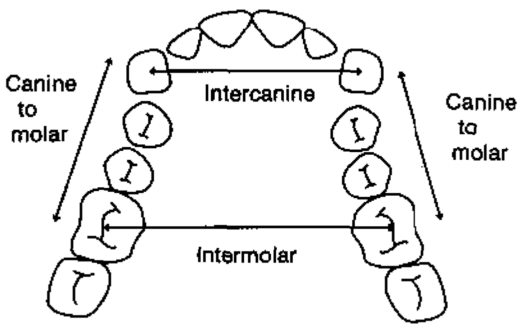

Figure 16.1 Sagittal and lateral measurements to be taken from both upper and lower arches

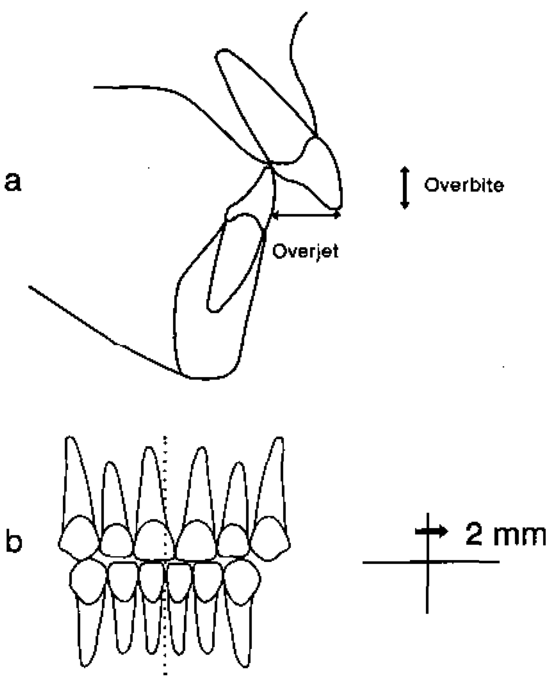

Figure 16.2 (a) Overbite and overjet measurement; (b) Centre-line recording

These points establish initial tooth positions (Figures 16.1 and 16.2) and the measurements should be taken and recorded at each visit. This will act as a record of tooth movement. For the inexperienced operator it will afford the opportunity to recognise unsatisfactory tooth movements at an early stage and institute appropriate action.

Attention to 'arch form' (Chapter 6), and the use of individualized arch forms will reduce the possibility of producing unwanted tooth movements.

Fixed appliance treatment will often involve the simultaneous movement of many teeth in three planes. Because of the possible complexity errors can easily occur. Any incorrect tooth movement should be corrected as soon as possible.

The need for monitoring and re-assessment at every visit cannot be overstated.

Appliance placement

Sufficient time should be set aside for fitting of the appliances. All relevant records should be available. It may be useful to use the reference models to assess where to place the brackets and transfer these points to the teeth. The quality of the final result will reflect the attention to detail in the correct positioning of the attachments at the initial stage of treatment.

Shortly after the fitting of a fixed appliance the patient may experience some mild discomfort. Careful counselling of the patient and parent is necessary to prepare them for these minor problems. Verbal instructions given to the patient and parent in the surgery should be reinforced by written instructions which are to kept by the patient (see Appendix 2).

Minor irritation from attachments can be relieved by the use of soft wax or silicone elastomer, a supply of which should be given to each patient together with the instruction sheet.

Fitting headgear

Great care must be exercised when fitting and adjusting headgear. Forces are generated from elastic traction and transmitted to the teeth through the facebow. If the bow is dislodged it may cause soft tissue injury. Severe injuries, including ocular damage have been reported. A headgear design which incorporates a safety feature preventing injury resulting from displacement of the facebow must be used.

The patient and parent must be informed of the possible dangers if the appliance is not worn correctly. Written instructions should be provided (see Appendix 2). The headgear appliance should be checked by the operator at every visit and the fact that this has been done recorded in the patient's notes.

Archwire placement

Although initial archwires can be placed at the time of bonding some operators will allow an

interval of a few days between bonding the brackets and placing the first archwires. There are good reasons for this, not least allowing the patient to adapt to the changed oral environment and the operator to assess motivation and oral hygiene.

Following any necessary extractions initial aligning and levelling archwires can be placed. Because of their flexibility these archwires can become distorted and cause soft tissue trauma. Long unsupported spans may cause ulceration of the lips or cheek, which can to some extent be prevented with the use of plastic or rubber tubing. The archwire ends should be turned down under the buccal tube or cut at the distal end of the molar tube.

Routine visits

After the initial visits for the fitting of the appliance, routine visits at 4–6-week intervals will need to be arranged. It is generally not necessary to see patients at less than monthly intervals unless there are problems with the appliance. The patient should be instructed to return as soon as possible if the appliance is damaged. Damaged appliances can cause unwanted tooth movements which may be difficult to correct.

At each visit a series of standard checks will need to be made. By adhering to an established routine the chances of not recognizing untoward tooth movements are reduced. Early corrective action can then be taken to ensure treatment is completed efficiently and effectively.

Ask the patient

Are there are any problems? Enquire about pain or discomfort. Some discomfort in the first few days can be expected although it should not persist. Particular attention should be drawn to the possibility of loose attachments or bands.

Check

Check for any loose bands and bonds. The patient is not always aware of such an occurrence and bands may be held in place due to close contact points although the cement has leached out. This will give rise to decalcification and carious lesions (Plate 26).

Examine the gingival condition, which is often an indication of the general standard of oral hygiene. Every effort should be made to ensure that the standard of oral hygiene is maintained at a high level throughout treatment.

Compare

The clinical situation should be compared with the original reference models and the notes made at the previous visit. It should be possible to assess the tooth movements achieved and treatment progress.

Measure

Measure the overjet, overbite, molar relationship, intercanine and intermolar width and record these in the notes. The measurements should be compared with those taken at the previous visit. Questions to be considered are:

- What tooth movements have occurred since the last visit?
- Is treatment progressing satisfactorily?
- If not, why not and what action must be taken?

Action

Adjustment of and alteration to the appliance will usually be necessary. Examine the headgear for wear and tear. Check how the patient inserts and removes the extra-oral appliance. For medico-legal reasons it is important that this examination is carried out and the fact recorded in the case notes. The archwires should be removed to be adjusted or replaced. This affords the opportunity for the patient to carry out a thorough brushing around the attachments and if necessary a prophylaxis to any areas which the patient finds difficulty in cleaning.

Record

Detailed recordings in the case notes will simplify management. Record the changes that have occurred and the adjustments and modifications carried out.

Next visit

A note should be made of the expected result at the next visit and the anticipated action that may need to be taken. These comments will help to highlight the important features to be addressed at the next visit. The ability to be able to think

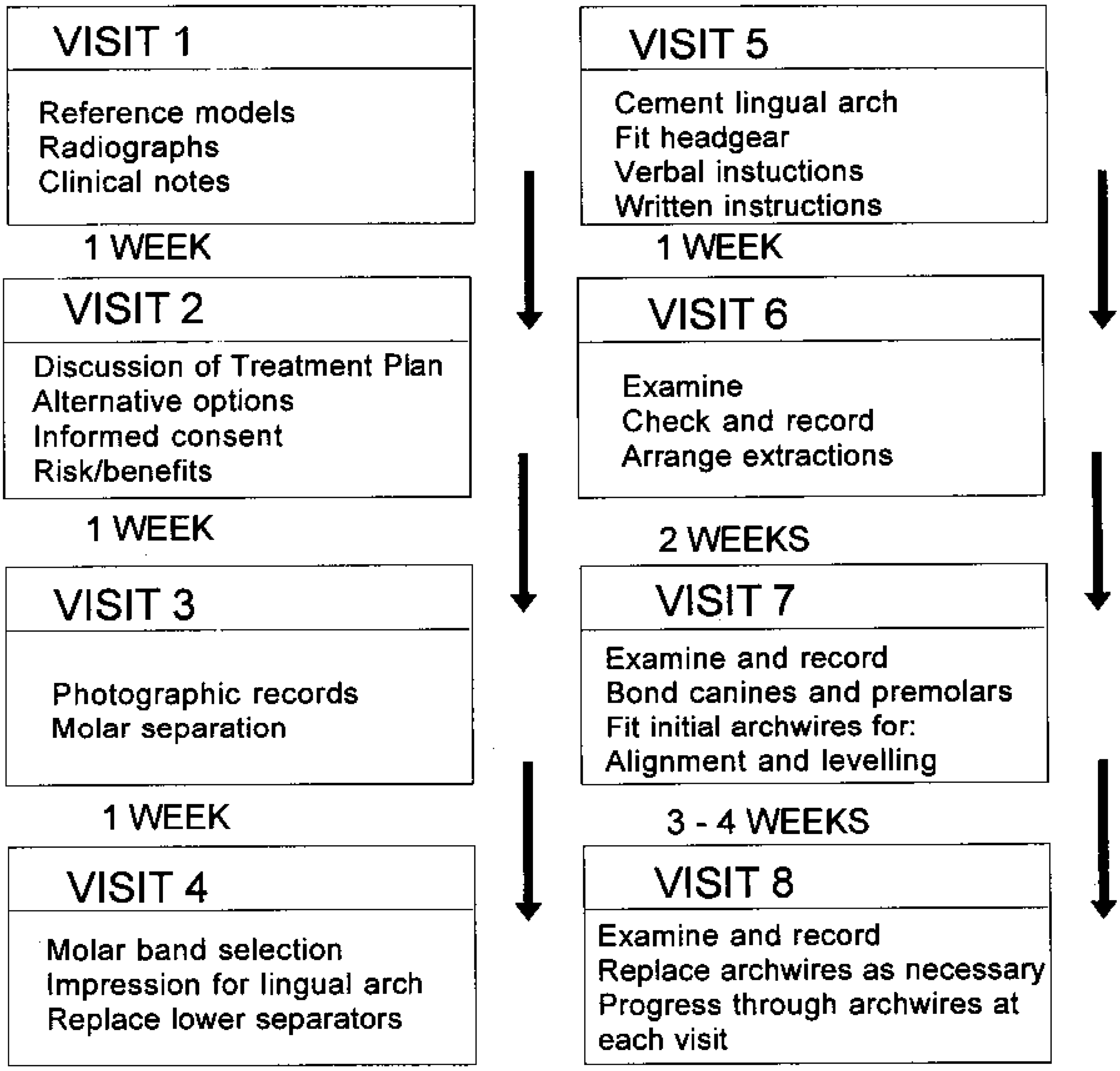

Figure 16.3 A suggested series of appointments for a treatment associated with extractions and headgear

and plan ahead in orthodontic treatment is of great help in identifying unsatisfactory changes in tooth position at an early stage and ensuring that corrective action is taken.

Clinical planning

Careful planning can make the most efficient use of chairside time.

A suggested protocol for an extraction treatment programme is given in Figure 16.3. In this example it is assumed that all the extraction space is required in the lower arch for relief of crowding and space loss cannot be allowed to occur. The upper arch anchorage is also critical and needs to be reinforced with headgear, which must be considered essential in this case in order to achieve the treatment goals.

This plan is only a general guide and should be modified for each clinical situation.

Some operators prefer to extract teeth before banding and bonding. However, in maximum anchorage cases where space is critical it is often advantageous to have the teeth under the control

of appliances and ensure that the patient can cope with the headgear before arranging extractions.

Patient motivation

All patients must demonstrate a high degree of motivation and commitment to treatment. When treating children and young adults it is necessary to assess whether this initial enthusiasm is likely to remain throughout the active treatment phase. Problems can arise in cases where the dental age is well in advance of chronological age. The clinical condition may indicate the need for treatment to start, but the patient's motivation may not be adequate. In such cases it is in the patient's best interest to delay treatment. In the majority of cases, treatment terminated before completion leaves the patient dentally disadvantaged.

Adult patients who embark upon orthodontic treatment are usually well-motivated. This high degree of compliance must be maintained throughout treatment. In many cases fitting the appliance and allowing a period of time for the patient to adjust before extractions are carried out is worthwhile.

Most patients will experience a period of frustration during the course of treatment. Counselling and involvement of the patient in the treatment progress can be of benefit. A careful explanation and demonstration of the tooth changes should be given to patients at regular intervals. The use of the initial reference models and photographs can be helpful.

Parent management

Parents naturally wish to be involved in their children's treatment. However, their presence in the surgery during complex and time-consuming procedures can be counter-productive. During banding and bonding procedures the patient's full concentration and attention is necessary. Young children are often distracted or behave in an inappropriate manner if parents are present. It is usually best to exclude the parent from the surgery during treatment and explain and demonstrate what has taken place afterwards. If children are being treated at boarding school good communication with the parents is necessary. A letter at the end of each term with a case summary is particularly useful if problems occur during holiday periods and another operator has to make adjustments to the appliance.

Clinical notes

It is best to keep orthodontic notes separate from general dental practice notes. This will ensure the orthodontic comments and measurements are kept in a logical sequence. It is essential to maintain concise and complete clinical records. Separate notes are also useful if the patient needs to be transferred to another operator during treatment.

In addition to the medical and dental history it is helpful to keep a summary of the treatment programme in a prominent position where it can easily be referred to at each visit. Orthodontic treatment extends over a considerable period of time. Not only should treatment goals be set but also an estimated finishing date. This is encouraging to the patient and parent and reminds the operator to ensure that treatment is proceeding within a satisfactory time scale.

Young patients can be encouraged to be involved in their treatment progress by bringing at each visit:

- appointment card;
- headgear and time sheet (recording the headgear wear);
- toothbrush and toothpaste;
- instruction sheets.

Failure of co-operation

During any extended course of treatment it is not unusual for co-operation occasionally to lapse. The important point from the orthodontist's point of view is to recognize this and take appropriate action at an early stage.

Failure of co-operation can usually be detected by clinical experience. However, some early indicators could include the following.

Failure to achieve the anticipated tooth movements

At every visit a comparison should be made with the original records. Insufficient tooth movement can then be identified at an early stage. The need for continual reference and comparison with the original records has been stressed.

It is important that the operator is able to impart to the patient that he or she knows co-operation is not matching the standard

required. A positive approach is necessary in order to find a practical solution.

If necessary the parents should be alerted in order that supportive action can be taken.

Frequent complaints and breakages

Problems invariably arise in the early stages of treatment when light flexible archwires are placed. These can and do distort easily and in the early stages the patient is learning to adapt to the changed oral environment. Most patients who are well motivated will accept and adapt to the constraints placed upon them while wearing fixed appliances. There will be a conscious effort to avoid activities and food stuffs that tend to damage the appliance.

Repeated breakages must be regarded as an indicator of poor co-operation. It is important to note the frequency and nature of these breakages in the notes. A picture of a poorly motivated patient may emerge allowing appropriate action to be taken.

Failed appointments

Well-motivated patients and parents will understand and appreciate the need for regular appointments to ensure continuity of care and satisfactory tooth movement.

Failure to keep appointments is often an indication of a lack of compliance on the part of the patient. Repeated failure to keep appointments will compromise treatment. It should be explained to the patient and parent that with such interruptions the anticipated end result cannot be achieved, treatment time will be longer and damage to the teeth and supporting structures may ensue. The result of such discussions should be carefully recorded in the notes as future reference to them may be necessary.

Repeated failed appointments will almost certainly require termination of treatment. An appropriate letter should be sent to the patient or parent indicating that the operator cannot take responsibility for unsupervised appliances, which will almost certainly damage the teeth and result in unsatisfactory tooth movement.

A request should be made for the patient to return to the surgery at the earliest opportunity in order to have the appliance removed. Many patients will return requesting continuation of treatment. The operator will need to consider the wisdom of this and discuss future management with the patient and, if a minor, a responsible adult. Detailed notes should be made.

Termination of treatment

The need to terminate treatment may come as a consequence of a request from the patient or a decision by the operator.

Termination by patient

Some patients, may feel they can no longer cope with the wearing of fixed appliances. They may be under the influence of peer pressure or feel compromised by their appliances when forming new relationships and friendships.

Many of these problems can be prevented by spending time before the placement of the appliances explaining the possible implications and time scale of wearing a fixed appliance.

Problems during treatment can often be resolved with careful counselling followed by a period of reflection on the part of the patient on the possible implications of terminating treatment.

If appliances are removed at the request of patient or the parent it is advisable to have this request in writing.

Termination by operator

Persistent poor co-operation, failure to keep appointments or poor oral hygiene may force the operator to discontinue treatment. This will be necessary if the likely benefits of orthodontic treatment are outweighed by the potential or real adverse affects.

By the time this irrevocable decision has been made the process of counselling and improving motivation would have been pursued. Careful notes should be made including details of the steps that had been taken previously and the reason for terminating treatment.

It must be stressed that it is far better not to start treatment than to have to terminate during a treatment programme. Rarely is there any benefit to either the patient or operator under such circumstances and more often there is a real detriment in a failure to complete treatment.

Successful orthodontic treatment requires a close understanding between the operator, the patient and in the case of children, the parents. Good communication is essential. Before commencing treatment the operator must be sure he is capable of carrying out the treatment to completion. The patient must understand the need for regular visits over many months, the necessity for a high standard of oral hygiene and the reason for carrying out treatment. Treatment aims must be clearly defined and agreed with the patient and parents.

Attention to detail at each visit and meticulous recording of tooth changes will contribute to satisfactory tooth movement and highlight inappropriate tooth movement that may be occurring.

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Appendix 1

The risks and benefits of orthodontic treatment

Benefits

The orthodontic treatment that has been suggested for you may have overall benefits in the appearance of your face and teeth and in maintaining good oral health.

Well aligned teeth are easier to keep clean and many patients will find their self esteem is enhanced by an attractive smile and dental appearance.

It is important to appreciate that not all these benefits may be appropriate to every individual patient. There is also great variation in each individual's response to treatment and this can, on occasions, affect the final result.

Risks

As with any form of treatment there are some risks associated with orthodontic treatment. While every effort is taken to minimize these risks, you, the patient, can help to minimize them by following treatment advice carefully and fully.

1. Tooth decay and enamel damage

Tooth decay and enamel damage can occur if sugary or acid foods are eaten and tooth brushing is not maintained at a high standard. This damage can occur at any time but is more likely when fixed appliances are attached to the teeth.

2. Root resorption

Orthodontic tooth movement involves light pressure being placed on the teeth and roots. In some patients changes such as root shortening may occur. The causes of this are not well understood and it is not always possible to identify susceptible patients in advance. In the majority of cases where this occurs there are no significant consequences.

3. Headgear

If not worn correctly, headgear may cause injury. It is imperative that the written instructions are followed when using a headgear appliance.

4. Joint discomfort

Some individuals may experience jaw joint discomfort during orthodontic treatment. This is usually a transitory phase and indeed such symptoms also occur in patients who are not wearing orthodontic appliances.

5. Post-treatment changes

Throughout life the position of teeth alters regardless of orthodontic treatment. Some aspects of orthodontic treatment are particularly prone to post-treatment changes.

Following fixed appliance treatment retainers will need to be worn. There are other changes, particularly the degree of crowding of the lower incisors, that may progressively alter throughout life.

6. Medical history

General medical problems may influence an individual's response to orthodontic treatment. It is important to inform your orthodontist of any changes in your medical health.

Appendix 2

Instructions for patients wearing fixed appliances

You are now wearing a **fixed appliance**. You must take great care of it.

You must

1. Clean your teeth with a brush, immediately after every meal and before going to bed. If your teeth are not kept clean damage will occur.
2. Avoid eating hard foods (such as crusty bread), and sticky food, (such as toffee and nougat).
3. Since it will be necessary to use a toothbrush after eating, most patients find it best to avoid snacks taken between main meals.
4. Contact the orthodontist if the appliance hurts, becomes loose, or if any part however small is broken.
5. Continue with your routine dental visits.

Initially there will be some difficulty in eating and speaking but this will soon pass.

You may experience some discomfort for a few hours following the placement of new archwires. This may be eased with a mild analgesic.

Instructions for patients wearing Headgear

You have been given **headgear**. You must take great care of it.

Extreme care should be used at all times when it is worn. You must

1. wear it for an average of .... hours a day;
2. wear it exactly as instructed, including any safety mechanism; failure to do so may cause damage;
3. ensure no one touches the headgear when it is being worn; if the bow is pulled forward out of the attachment it may spring back causing facial damage;
4. keep a record of the hours worn on the sheet provided;
5. bring your headgear and record of wear at each visit; the appliance will need to be adjusted and checked;
6. contact the orthodontist if the appliance hurts, becomes loose, or if any part however small is damaged;
7. stop wearing the headgear, and contact the orthodontist if the bow comes out at night.

You must not

1. wear the headgear if any part becomes loose, broken or uncomfortable;
2. wear the headgear during sports or other activities where you may be in close contact with other people.

Instructions for patients wearing elastic bands

You now need to wear small elastic bands to help tooth movement.

You must

1. wear the elastics exactly as you have been shown;
2. carry a supply of elastic bands in order that any broken ones can be replaced immediately;
3. replace the elastics with new ones every day;
4. contact the surgery if you run out of elastics.

Remember that failure to follow these instructions will prolong your orthodontic treatment.

Appendix 3

Orthodontic supply companies

Note: This is not a comprehensive list.

American Orthodontics Ltd
Forge Works
Lane End
High Wycombe
Bucks HP14 3HJ
Tel: 01494 882561
Fax: 01494 883351

Eurodontic Ltd
85 Harwood Street
Sheffield S2 4SE
Tel: 01142 766813
Fax: 01142 766813

RMO Europe
Rue Geiler de Kaysersberg
BP 221
67406 Illkirch Cedex
France
Tel: 88.40.6740

Forestadent Ltd
21 Carters Lane
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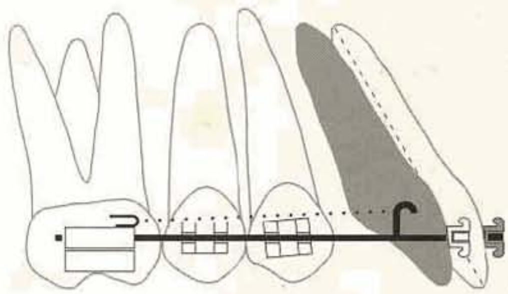

An increasing awareness of the benefits of orthodontic treatment, together with advances in both the sophistication and capability of fixed orthodontic appliances, have stimulated a great deal of interest from both dental practitioners and patients. Modern materials offer much improved physical characteristics and the availability of 'aesthetic' appliances has resulted in an incease in the number of patients requesting treatment. However, the readiness with which fixed appliances can now be provided carries with it the danger of their use in inexperienced hands, and the purpose of this book is to provide the newcomer to orthodontics with an understanding of the basic principles involved as well as the mechanisms appropriate for moving teeth with fixed appliances. It also gives general guidance on how to position teeth in order to achieve optimum functional, aesthetic and stable results.

Emphasis has been placed on simplicity and clarity, and the book is profusely illustrated with numerous line drawings and colour plates.

Fixed Orthodontic Appliances should be essential reading for any graduate commencing orthodontic training, as well as for the interested general practitioner and final year student.

wright

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